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Fishes of Worldwide (Circumtropical) Distribution

John C. Briggs

Introduction

In these days of concentration on fishes of relatively restricted areas, by means of regional checklists, circumscribed faunal works, and geographically limited revisions, one is apt to forget that many fishes are relatively unrestricted in distribution, and therefore cannot be said to belong to any one zoogeographic area. Although they may tend to interfere with attempts to give precise definition to the various zoogeographic regions, such species must not be overlooked, as they form an undeniable and interesting part of the general pattern of the dispersal of marine fishes.

The purpose of this contribution is to call attention to those forms which are apparently worldwide in distribution, in the hope that they may receive additional consideration. It should be emphasized that the majority of the species mentioned in this work have not been subjected to recent systematic appraisal. Consequently, it is expected that this list will undergo considerable change in the near future.

The following annotated list of 107 species includes only those which, according to the present state of our knowledge, form homogeneous species populations extending entirely around the world in tropical or temperate waters. Fishes that seem to be worldwide at the species level but that apparently break up into subspecific populations in parts of their range are not included. Under each species are listed only those recent references that seem to give a reasonably good indication of circumglobal distribution. In many instances, these references are reinforced by the citation of a definite record from the Eastern Pacific area. Several species have been listed for which no Indian Ocean captures are yet known. Presumably, this is a reflection of the paucity of collections from that region rather than an actual discontinuity in the range of the species.

Worldwide fishes were found to occupy four different marine habitats. The "shore" species are those found in waters that overlie the continental shelf where the depth is less than 200 meters (109 fathoms). "Pelagic" fishes generally inhabit the surface layers of water—at depths of less than 200 meters—in the offshore regions, usually beyond the limits of the continental shelf. Species inhabiting the offshore waters below 200 meters, but not including the sea bottom, are in the "bathypelagic" zone. The "benthic" forms are bottom fishes found at depths greater than 200 meters. In many cases the designation of habitat has been quite arbitrary, especially in regard to the pelagic versus the shore species. For example, many of the carangids are fast swimmers and exhibit a body shape and coloration that is apparently well adapted to a pelagic existence yet they may be most often caught in relatively shallow water. Perhaps such fishes should be placed in a special "shore-pelagic" category.

Although relatively few of the total number of recent fish families are represented on this list, it can be seen that worldwide species have cropped up at many different evolutionary stages. At the primitive extreme, it may be noted that there are not only many cosmopolitan elasmobranchs but that two lancelets, *Asymmetron lucayanum* Andrews and the larval *Amphioxides pelagicus* (Günther), have almost achieved a similar distribution, since they are missing only from the Eastern Pacific. At the other end of the scale, we find several plectognaths and at least ten ceratioid species with circumglobal distributions.

As one might suspect, there is a high percentage of wide-ranging species in the families that have exploited the pelagic and bathypelagic environments most successfully.

Shore Fishes

Despite the fact that the species of marine shore fishes are exceedingly numerous, it is still surprising to find that 14 stray from their littoral habitat, as larvae or adults, often enough to establish worldwide populations.

Ekman (1953:73), as well as a number of others, has emphasized that the broad expanse of open ocean between Polynesia and America is responsible for the most pronounced break in the circumtropical shore fauna. Since we have noted that 14 shore fishes have been able to cross this "East Pacific Barrier" to establish worldwide ranges, the question may arise as to just how effec-

tive is the barrier in limiting the distribution of shore species that have shown the ability to become widely dispersed in other parts of the world? A search of the ichthyological literature reveals that apparently only five or six shore species are well established in the warm waters of all oceans but the Eastern Pacific. These are the southern lancelet, *Asymmetron lucayanum* Andrews, the snakefish *Trachinocephalus myops* (Forster), the ruby snapper *Etelis carbunculus* (Cuvier)—usually known as *E. oculatus* (Cuvier) in the Western Atlantic, the great barracuda *Sphyraena barracuda* (Walbaum), and the bristle filefish *Stephanolepis setifer* (Bennett). To these five may be added the flat needlefish *Ablennes hians hians* (Valenciennes) if it should be properly considered a shore instead of a pelagic species. The black triggerfish *Melichthys radula* (Solander) and the smooth triggerfish *Canthidermis maculatus* (Bloch) are not included because these forms have apparently succeeded in crossing the major portion of the barrier in becoming established around certain offshore islands of the Eastern Pacific.

These data make possible a generalization that seems justified in the light of our present knowledge about the species concerned: Of those tropical shore fishes that have a broad distribution elsewhere (on both sides of the Atlantic, the Indian Ocean, and the Western Pacific), *the majority* have been able to cross the East Pacific zoogeographic barrier.

The foregoing statement is applicable only to the wide-ranging shore fishes. For other shore species, which constitute an overwhelming majority, the East Pacific barrier is very effective indeed. Its efficiency depends not only on distance, as has been generally assumed, but also on ecological factors.

Bathypelagic and Pelagic Fishes

As would be expected, by far the majority of fishes showing a worldwide distribution can be considered as typical of the open ocean waters. The 42 bathypelagic and 48 pelagic species comprise 84.1 percent of the entire list. During the process of compiling distributional records, it was noted that an impressive number of these species are apparently affected by the same East Pacific Barrier that operates so noticeably on the shallow-water marine fauna.

No fewer than 28 species of bathypelagic fishes, which show evidence of a broad distribution in the other oceans, have failed to become established in the Eastern Pacific. A similar pattern is shown by at least 15 of the pelagic forms. Many of these bathypelagic species are infrequently captured and are difficult to properly identify and the same can be said for at least a few of the pelagic fishes. For this reason, the absence of so many from the Eastern Pacific may be more apparent than real. With regard to the present distributional picture, however, it can be stated that more than one-third of the wide-ranging bathypelagic and pelagic fishes are evidently prevented from achieving a worldwide distribution by their inability to cross the East Pacific Barrier.

If in the light of future investigations the East Pacific Barrier (previously considered to be operative only in the case of the littoral fauna) continues to appear effective for bathypelagic and pelagic fishes, it may be concluded that many species, usually considered to be well adapted to life in the open ocean, may actually be dependent on a certain degre[e] of proximity to land masses or to relat[ively] shallow water areas.

[Ra]pid progress in systematic work on the [bathy]pelagic fishes is yielding increasing evidence of the wide distribution of a large percentage of the species. At present only a few of these forms are known from waters deeper than 2000 meters (1000 fathoms). Most of the 17 species from such depths listed by Grey (1956:311–2) are already held to be very widely dispersed; seven are worldwide and two more have been taken from almost all areas except the Eastern Pacific.

Benthic Fishes

Although our knowledge of the benthic fishes is still very limited, it may be said that, in general, their dispersal is quite restricted. Grey (1956:304) gives a distributional list of benthic species that have been taken below a depth of 2000 meters.

As may be noted by reference to the list herein presented, only three benthic fishes were found to have a circumtropical distribution. As matters now stand, there is, among the wide-ranging members of this group also, some indication of an unexpected scarcity in the Eastern Pacific. Such species as *Heptranchias perlo* (Bonnaterre), *Dalatias licha* (Bonnaterre), *Bathysaurus ferox* Günther, *Ipnops murrayi* Günther, *Synaphobranchus kaupi* Johnson, *Venefica procera* (Goode and Bean), *Chascanopsetta lugubris* Alcock, *Nematonurus armatus* (Hector) seem to have a broad distribution elsewhere but, so far, there is no

indication of their presence in the depths of the Eastern Pacific area.

Annotated List

Family Hexanchidae

1. *Hexanchus griseus* (Bonnaterre)—sixgill cowshark. Benthic. A species from moderately deep water, usually 75–300 fathoms. Good evidence for a cosmopolitan distribution is given by Bigelow and Schroeder (1948:80–7).

Family Isuridae

2. *Carcharodon carcharias* (Linnaeus)—white shark. Pelagic. Good evidence for a cosmopolitan distribution is given by Bigelow and Schroeder (1948:134–45).

Family Cetorhinidae

3. *Cetorhinus maximus* (Gunner)—basking shark. Pelagic. Although this species is almost always taken in cold or temperate waters, it is found in both northern and southern hemispheres indicating some movement across the equatorial regions. Range from Bigelow and Schroeder (1948:147–60).

Family Alopiidae

4. *Alopias vulpinus* (Bonnaterre)—common thresher. Pelagic. Considered to be worldwide, although the Western Pacific species may be distinct from the *A. vulpinus* of the other oceans, according to Bigelow and Schroeder (1948:167–78).

Family Rhineodontidae

5. *Rhineodon typhus* Smith—whale shark. Pelagic. Reliable reports from the tropical waters of all oceans are listed by Bigelow and Schroeder (1948:193–5).

Family Carcharhinidae

6. *Galeocerdo cuvieri* (Peron and Lesueur)—tiger shark. Shore. Well substantiated records from the tropical and subtropical portions of all the oceans are summarized by Bigelow and Schroeder (1948:271–5).
7. *Prionace glauca* (Linnaeus)—great blue shark. Pelagic. Many records from all oceans. Also has a wide latitudinal range, according to Bigelow and Schroeder (1948:282–92).
8. *Carcharhinus limbatus* (Müller and Henle)—blacktip shark. Pelagic. Considered by Bigelow and Schroeder (1948:346–53) to have a worldwide range, although there may be some doubt about the literature records from the Western Pacific and Indian Oceans.
9. *Carcharhinus longimanus* (Poey)—whitetip shark. Pelagic. Rosenblatt and Baldwin (1958:148) call attention to the worldwide distribution of this species.

Family Sphyrnidae

10. *Sphyrna tiburo* (Linnaeus)—bonnethead. Shore. Although Bigelow and Schroeder (1948:425) thought that this species was not likely to be found in Indian or Western Pacific waters, Herre (1953:27–8) includes it on his Philippine list and gives additional records.
11. *Sphyrna zygaena* (Linnaeus)—common hammerhead. Shore. Good evidence for a cosmopolitan range is given by Bigelow and Schroeder (1948:436–49).
12. *Sphyrna mokarran* (Rüppell)—great hammerhead. Pelagic. This species is the same as that called *S. tudes* by Bigelow and Schroeder (1948:428–36). Tortonese (1950:1030–3) corrected the nomenclature after an examination of the types. He also states that it definitely occurs in the Indo-Pacific and should be considered worldwide.

Family Dalatiidae

13. *Isistius brasiliensis* (Quoy and Gaimard). Pelagic. As Bigelow and Schroeder (1948:509–14) show, there is little doubt that this distinctive species is indeed worldwide.

Family Echinorhinidae

14. *Echinorhinus brucus* (Bonnaterre)—bramble shark. Shore. This rare species is at present to be considered to be cosmopolitan, as by Bigelow and Schroeder (1948:527–32), but more than one form may be included.

Family Squalidae

15. *Squalus fernandinus* Molina. Pelagic. The recent description of three Western Atlantic specimens by Bigelow, Schroeder, and Springer (1953:221) established a circumtropical range for this species. Chilean range is given by Mann (1954:108).

Family Mylobatidae

16. *Aetobatus narinari* (Euphrasen)—spotted duckbill ray. Shore. The circumtropical range of this ray is well established. The most complete modern account is that of Bigelow and Schroeder (1954:453–65).

Family Mobulidae

17. *Manta birostris* (Walbaum)—manta. Pelagic. Considered to be circumtropical although, according to Bigelow and Schroeder (1954:511), there is some doubt about the specific relationship of the Atlantic and Pacific populations.

Family Albulidae

18. *Albula vulpes* (Linnaeus)—bonefish. Shore. Circumtropical range is shown by Smith (1949:436). Eastern Pacific records are listed by Fowler (1944:481).

Family Sternoptychidae

According to the literature on the genus *Argyropelecus*, there are three species (*A. affinis* Garman, *A. olfersi* (Cuvier), and *A. sladeni* Regan) which could be considered worldwide in distribution. However, Dr. Leonard P. Schultz has in press a review of this group and he has written (personal communication) that he has no evidence of such broad distribution for any of the species.

19. *Sternoptyx diaphana* Hermann. Bathypelagic. As was mentioned by Haig (1955:319), this species has been reported from many parts of the Atlantic, Indian, and Pacific oceans.

Family Gonostomatidae

20. *Cyclothone microdon* (Günther)—smalltooth bristlemouth. Bathypelagic. Listed by Smith (1949:437) as occurring in all oceans but the Eastern Pacific. Recorded from California by Hubbs and Follett (1953:11).
21. *Cyclothone pallida* Brauer—bicolored bristlemouth. Bathypelagic. Listed for the Bahama Islands by Fowler (1944: 436), from the Eastern Atlantic and Indian oceans by Fowler (1936:226), and from California by Hubbs and Follett (1953:11). The evidence for a worldwide distribution seems quite good despite the absence of a Western Pacific record.
22. *Cyclothone signata* Garman—showy bristlemouth. Bathypelagic. Considered to have a worldwide distribution by Smith (1949:437). Presence in Eastern Pacific is verified by Fowler (1944:484) and Hubbs and Follett (1953:11).
23. *Cyclothone acclinidens* Garman—benttooth bristlemouth. Bathypelagic. Grey (1956:126) lists records that demonstrate a cosmopolitan occurrence. However, she notes that *C. acclinidens* is very close to *C. microdon* and suggests that the two species have been confused at times.
24. *Maurolicus muelleri* (Gmelin). Bathypelagic. Recognized as occurring in all oceans except the Eastern Pacific by Smith (1949:437). Listed from the Pacific coast of South America by Fowler (1944: 484).
25. *Vinciguerria nimbaria* (Jordan and Williams). Bathypelagic. From unpublished information based on a personal communication from Mrs. Marion Grey and from the recent paper by Ahlstrom and Counts (1958:405–9).

Family Stomiatidae

Although Ege (1934:9) in his revision of the genus *Stomias* indicates a worldwide distribution for *S. affinis* Günther, Dr. Carl L. Hubbs (personal communication) states that neither of the two Eastern Pacific species is referable to this form.

Family Idiacanthidae

A circumtropical distribution for *Idiacanthus fasciola* Peters is indicated by Smith (1949:437) but Dr. Carl L. Hubbs writes (pers. comm.) that it has not been taken in the Eastern Pacific.

Family Neoscopelidae

26. *Neoscopelus macrolepidotus* Johnson. Bathypelagic. The general occurrence is given by Fraser-Brunner (1949:1039) as "temperate and warm seas."

Family Myctophidae

27. *Ceratoscopelus townsendi* (Eigenmann and Eigenmann). Bathypelagic. Bolin (1959:37) states that this species occurs commonly in a broad circumglobal belt between the latitudes of approximately 35°N, and S.
28. *Notoscopelus resplendens* (Richardson). Bathypelagic. A circumglobal range for this species is indicated by Bolin (1959: 40).
29. *Lampadena luminosa* Garman. Bathy-

pelagic. A worldwide distribution between 25°N and 30°S. latitude reported by Dr. Rolf L. Bolin (pers. comm.).

30. *Loweina rara* (Lütken). Bathypelagic. This is a circumglobal species having been taken between 25°N. and 35°S. latitude (Bolin, pers. comm.).
31. *Diogenichthys atlanticus* (Tåning). Bathypelagic. Bolin (1959:11) considers that it is probable that this species has a worldwide distribution between the latitudes of 40°N. and S.
32. *Notolychnus valdiviae* (Brauer). Bathypelagic. There are numerous records from the Atlantic, Pacific and Indian oceans showing this to be a circumglobal species inhabiting a wide temperature range according to Bolin (1959:23).
33. *Gonichthys barnesi* Whitley. Bathypelagic. Bolin (1959:17) mentions that this species is distributed around the world between 30° to 40°S. latitude.
34. *Lepidophanes pyrsobolus* (Alcock). Bathypelagic. Bolin (1959:37) shows this to be a circumtropical form between 35°N. and 35°S. latitude.
35. *Lampanyctus nobilis* Tåning. Bathypelagic. Bolin (pers. comm.) states that this species is circumglobal in a broad area between 20°N. and 20°S. latitude. It has been confused with *L. macropterus* (Brauer).
36. *Lampanyctus niger* Günther. Bathypelagic. Although restricted to the southern hemisphere, this species extends entirely around the world and occurs as far north as 35°S. latitude (Bolin, pers. comm.).
37. *Lampanyctus tenuiformis* (Brauer). Bathypelagic. Beebe and Vander Pyle (1944: 87) show an Eastern and Western Atlantic, Indian Ocean, and Eastern Pacific distribution. Fraser-Brunner (1949:1087) mentions the Indian Ocean. Despite the lack of a Western Pacific record, this species is probably a worldwide form.
38. *Lympanyctus festivus* Tåning. Bathypelagic. According to information from Bolin (pers. comm.), this species is probably circumglobal but it has often been confused with *L. tenuiformis*.
39. *Diaphus dumerili* (Bleeker). Bathypelagic. Beebe and Vander Pyle (1944:88) show a distribution for all major areas except the Indian Ocean. However, Fraser-Brunner, (1949:1086) indicates its presence there, Bolin (pers. comm.) writes that it is found between 35°N. and 25°S. latitude.
40. *Lobianchia gemellari* (Cocco). Bathypelagic. The only major oceanic area from which this species is not reported by Beebe and Vander Pyle (1944:89) and by Fraser-Brunner (1949:1066) is the Western Pacific. Despite this, the species probably has a worldwide distribution. Bolin (1959:20) points out that this species has been confused with *L. dofleini* (Zugmayer).
41. *Centrobranchus nigroocellatus* (Günther). Bathypelagic. Bolin (1959:18) says that this species, as presently understood, appears to be circumglobal between the latitudes of 35°N. and 30°S.
42. *Benthosema suborbitale* (Gilbert). Bathypelagic. According to Bolin (1959:11), this species appears to have a worldwide distribution in tropical or subtropical waters and, in regions where currents carry warm water to the north or south, it may be taken at or even somewhat beyond the latitudes of 50°.
43. *Taaningichthys bathyphilus* (Tåning). Bathypelagic. Bolin (1959:26) states that the comparatively few captures indicate a circumglobal range between about 30°N. and 26°S. latitude.
44. *Triphoturus nigrescens* (Brauer). Bathypelagic. Bolin (pers. comm.) finds this to be worldwide between 24°N. and 37°S. latitude.

Family Scopelarchidae

45. *Scopelarchus analis* Brauer—common pearleye. Bathypelagic. Records for the Eastern Atlantic, Indian, and Antarctic oceans are cited by Fowler (1936:354). Listed for Bahama Islands by Fowler (1944:438) and for California by Hubbs and Follett (1953:17).

Family Eurypharyngidae

46. *Eupharynx pelecanoides* Vaillant—gulper. Bathypelagic. A summary of the distributional records for this species is given by Grey (1956:139).

Family Nemichthyidae

47. *Nemichthys scolopaceus* Richardson—common snipe-eel. Bathypelagic. Occurrences in the North Atlantic, Mediterranean, Indian Ocean, and Western Pacific listed by Beebe and Crane (1937: 353), and it was recently recorded from California by Hubbs and Follett (1953: 18).
48. *Cyema atrum* Günther—bobtail snipe-

eel. Bathypelagic. Grey (1956:151) gives a multitude of records from all oceans which show this to be a common, worldwide species.

Family Regalicidae

49. *Regalecus glesne* (Ascanius)—oarfish. Pelagic. Presence in all oceans but the Eastern Pacific was indicated by Smith (1949:440). Recorded from California by Hubbs and Follett (1953:20).

Family Trachipteridae

50. *Trachipterus cristatus* Bonelli—scalloped ribbonfish. Pelagic. Circumtropical range based on a personal communication from Dr. Vladimir Walters who with Mr. John E. Fitch and Dr. Richard H. Backus is revising this family.
51. *Trachipterus polystictus* Ogilby—polka-dotted ribbonfish. Pelagic. Circumtropical range based on a personal communication from Dr. Vladimir Walters.

Family Lophotidae

52. *Lophotus capellei* Temminck and Schlegel—crestfish. Pelagic. Worldwide range indicated by Briggs (1952:206).

Family Lampridae

53. *Lampris regius* (Bonnaterre)—opah. Pelagic. Smith (1949:440) gives a circumtropical range. Presence in the Eastern Pacific is verified by Hubbs and Follett (1953:19).

Family Macrouridae

54. *Gadomus longifilis* (Goode and Bean)—rattail. Benthic. Parr (1946:10) accepts this species as cosmopolitan but Grey (1956:166) remarks that it may be confined to the Atlantic.

Family Moridae

55. *Antimora rostrata* Günther. Benthic. Grey (1956:160) lists many records that show this to be a rather common, worldwide species.

Family Anoplogastridae

56. *Anoplogaster cornuta* Valenciennes—fangtooth. Bathypelagic. Norman (1930:347) gives records (listed as *Caulolepis longidens*) from the Atlantic, California coast, and Hawaiian Islands. Mrs. Marion Grey has further evidence (unpublished) that suggests a worldwide distribution.

Family Melamphaidae

According to the published literature on this family, both *Melamphaes mizolepis* (Günther) and *M. nigrescens* Brauer should be considered circumtropical. However, Dr. Alfred W. Ebeling is completing a study on this group and advises (pers. comm.) that the above species are replaced, in the Eastern Pacific, by related forms.

Family Priacanthidae

57. *Priacanthus cruentatus* (Lacépède)—bigeye. Shore. Herre (1953:375) and others indicate the range as Atlantic (both sides) to the Indo-Pacific. However, there are specimens in both the University of British Columbia and the University of California at Los Angeles collections from San Lucas Bay, Baja California, and Dr. Boyd Walker has recently provided information (via personal communication) about a U.C.L.A. specimen from Panama Bay.

Family Carangidae

58. *Naucrates ductor* (Linnaeus)—pilotfish. Pelagic. The records for this common, widespread species are most recently compiled by Herre (1953:274).
59. *Elagatis bipinnulatus* (Quoy and Gaimard)—rainbow runner. Pelagic. Herre (1953:272) agrees with most previous authors in listing the range as circumtropical.
60. *Selar crumenophthalmus* (Bloch)—bigeye scad. Pelagic. Records of this common, worldwide species are summarized by Herre (1953:280).
61. *Caranx hippos* (Linnaeus)—common jack. Pelagic. As Smith (1949:447) shows in his distributional chart, this species has been commonly believed to occur in all oceans but the Eastern Pacific. However, Mr. Frederick H. Berry has just published (1959:438) a revision of the Western Atlantic members of the genus in which he considers this and the two following species to be circumtropical in distribution.
62. *Caranx lugubris* (Poey)—tinosa. Pelagic. Circumtropical range recently established by Berry (1959:438).
63. *Caranx dentex* (Bloch and Schneider)—guara. Pelagic. Circumtropical range recently established by Berry (1959:438).

Family Coryphaenidae

64. *Coryphaena hippurus* Linnaeus—dolphin. Pelagic. The distribution of this common, worldwide species is most recently summarized by Gibbs and Collette (1959:136).
65. *Coryphaena equiselis* Linnaeus—pompano dolphin. Pelagic. Gibbs and Collette (1959:136) state that this species appears to be cosmopolitan in warm seas. Earlier authors are in agreement.

Family Gempylidae

66. *Ruvettus pretiosus* Cocco—escolar. Pelagic. Most recent account is that of Herre (1953:253), who considers this to be a circumtropical species. Presence in Eastern Pacific is verified by Hubbs and Follett (1953:25).
67. *Lepidocybium flavobrunneum* (Smith). Pelagic. Presence in the Atlantic, Indian, and Western Pacific oceans is indicated by the distributional chart of Smith 1949:455). Occurrence in California is listed by Hubbs and Follett (1953:25).
68. *Gemplyus serpens* Cuvier—snake mackerel. Pelagic. Herre (1953:252) gives a circumtropical distribution. Its presence in the Eastern Pacific is verified by Fowler (1944:499).

Family Bramidae

69. *Brama brama* (Bonnaterre)—common pomfret. Pelagic. Smith (1949:455) indicates a scattered, worldwide distribution (under the designation of *Brama raii*). Presence in the Eastern Pacific is verified by Hubbs and Follett (1953:24). It is a common offshore species in British Columbia waters.
70. *Taractes longipinnis* Lowe. Pelagic. This rare species may now be considered worldwide. In a recent review of the genus, Mead (1957:51–61), found it to occur on both sides of the Atlantic and in the Eastern Pacific. Kamohara (1952: 33) describes and figures a large individual from Japan (under the designation of *Taractes principes*).

Family Scombridae

71. *Thunnus alalunga* (Gmelin)—albacore. Pelagic. Smith (1949:454) shows a distribution in all oceans but the Eastern Pacific. Hubbs and Follett (1953:25) note its occurrence in Californa waters. Rivas (1951:222) mentions a lack of authentic Western Atlantic records but Bullis and Mather (1956:8) supply these.
72. *Thunnus obesus* Lowe—bigeye tuna. Pelagic. If the Bigeye tuna of the Pacific, *Thunnus mebachi* (Kishinouye)—often called *T. sibi* Temminck and Schlegel, is the same as that of the Atlantic, then there is but one worldwide species. Fraser-Brunner (1950:144) is of this opinion.
73. *Katsuwonus pelamis* (Linnaeus)—ocean bonito. Pelagic. Herre (1953:249) gives the range as cosmopolitan in temperate and tropic waters. Presence in the Eastern Pacific is verified by Hubbs and Follett (1953:25).
74. *Auxis thazard* (Lacépède)—frigate mackerel. Pelagic. This common species is listed for all tropical and warm seas by Herre (1953:247). Its presence in the Eastern Pacific is verified by Fowler (1944:498).
75. *Acanthocybium solanderi* (Cuvier)—wahoo. Pelagic. Herre (1953:245) gives a wide Indo-Pacific distribution and mentions that it is apparently identical with the West Indian form. Recorded from Ceylon by Munro (1955:220) and from the Eastern Pacific by Ricker (1959:13). Since this fish is clearly named by Cuvier (*in* Cuvier and Valenciennes) after Daniel Solander, a pupil of Linnaeus, the specific name should be written *solanderi*—not *solandri*, as is usually done.

Family Xiphiidae

76. *Xiphias gladius* Linnaeus—swordfish. Pelagic. Herre (1953:256) and almost all previous authors list this species for all tropical and temperate seas.

Family Istiophoridae

77. *Makaira nigricans* Lacépède—blue marlin. Pelagic. As the result of a comparison of Atlantic and Pacific specimens, Dr. C. Richard Robins (mimeographed Progress Rept. No. 6, The Charles F. Johnson Oceanic Gamefish Investigations, 1960) concludes that the blue marlin is a single, worldwide species.

Family Tetragonuridae

78. *Tetragonurus atlanticus* Lowe—squaretail. Pelagic. A cosmopolitan distribution for this species is shown by Grey (1955:33) in her revision of the genus.

Family Mugilidae

79. *Mugil cephalus* Linnaeus—striped mullet. Shore. Although most authors consider this to be a single, worldwide species, some recent evidence indicates that detailed morphological investigation will disclose a complex of species or subspecies (see de Sylva, Stearns, and Tabb, 1956:1–45).

Family Echeneidae

80. *Remora remora* (Linnaeus)—remora. Pelagic. Herre (1953:775) states that this species is found in all warm seas. Presence in the Eastern Pacific is verified by Hubbs and Follett (1953:24).
81. *Phtheirichthys lineatus* (Menzies). Pelagic. The distribution shown by Smith (1949:457) includes all oceans but the Eastern Pacific. Recorded from this area by Fowler (1944:518).
82. *Remoropsis brachyptera* (Lowe)—gray marlinsucker. Pelagic. A worldwide distribution except for the Eastern Pacific shown by Smith (1949:457). Recorded from California by Hubbs and Follett (1953:24).
83. *Remilegia australis* (Bennett). Pelagic. Jordan, Evermann, and Clark (1930: 449) quote a record by Lütken from the Western Atlantic (10°N., 30°W.). Smith (1958:319) recently reported this species from South Africa and gives literature records for the Indian Ocean, Western Pacific, and Eastern Pacific.
84. *Remorina albescens* (Temminck and Schlegel)—mantasucker. Pelagic. Listed for the Brazilian area (Santos) by Fowler (1941:177). Maul (1956:66) describes a specimen from Madeira and Smith (1949:457) shows a distribution from South Africa to the Western Pacific. There are many records for the Eastern Pacific, that of Hubbs and Follett (1953: 24) being the most recent.
85. *Rhombochirus osteochir* (Cuvier)—hardfin remora. Pelagic. This distinctive species was once thought to be confined to the warm waters of the Western Atlantic and the Eastern Pacific. However, Fowler (1949:143) identified it from Hawaii and Maul (1956:26) examined specimens from the Eastern Atlantic and Dutch New Guinea.

Family Rachycentridae

86. *Rachycentron canadus* (Linnaeus)—crabeater. Shore. Range given by Herre (1953:287) as "all warm seas but Eastern Pacific." However, it is recorded from the coast of Chile (Iquique) by Fowler (1944:502).

Family Pomatomidae

87. *Pomatomus saltatrix* (Linnaeus)—bluefish. Pelagic. Shown from all oceans but the Eastern Pacific by Smith (1949:448). Recorded from the coast of Chile (Valparaiso) by Fowler (1944:502).

Family Centriscidae

88. *Macrorhamphosus gracilis* (Lowe)—slender snipefish. Pelagic. In her fine revision of the family, Mohr (1937:61) shows a worldwide distribution for this species.
89. *Macrorhamphosus scolopax* (Linnaeus) —snipefish. Pelagic. A worldwide distribution similar to that of the above species, according to Mohr (1937:61).

Family Chiasmodontidae

90. *Chiasmodon niger* Johnson—black swallower. Bathypelagic. This interesting species is recorded by Norman (1930:349) from the Caribbean Sea and the Atlantic and Indian oceans. Listed from California by Hubbs and Follett (1953:34).

Family Diodontidae

91. *Diodon holacanthus* Linnaeus—balloon fish. Shore. Smith (1949:463) shows a distribution to all oceans except the Eastern Pacific. Recorded from a number of Eastern Pacific localities by Fowler (1944:527).
92. *Diodon hystrix* Linnaeus—porcupine fish. Shore. As in the case of the above species, Smith's (1949:463) distributional chart indicates an occurrence in all major areas but the Eastern Pacific. The most recent record from this area is that of Hubbs and Follett (1953:38).

Family Molidae

93. *Mola mola* (Linnaeus)—headfish. Pelagic. In his recent revision of the family, Fraser-Brunner (1951:113), gives an extensive synonymy which demonstrates a worldwide distribution.
94. *Ranzania laevis* (Pennant)—slender mola. Pelagic. The recent revision by Fraser-Brunner (1951:96) shows a worldwide distribution for this species too.

Family Balistidae

95. *Xanthichthys ringens* (Linnaeus)—redtail triggerfish. Shore. Clark (1949:10) indicates that *X. lineopunctatus* (Hollard), a widespread Indo-Pacific species, is the same as *X. ringens* (Linnaeus) of the Atlantic. It is reported, under the former name, from California by Hubbs and Follett (1953:38).

Family Aluteridae

96. *Alutera monoceros* (Osbeck)—unicorn filefish. Shore. The only Eastern Pacific record for this distinctive species seems to be that of Hiyama in the book by Kumada (1937:54, pl. 86) from somewhere along the Mexican coast. However, there is a specimen in the U. B. C. collection (BC60-31) taken by Mr. Tony Pletcher 2.5 miles south of Mazatlán, Sinaloa, Mexico, on July 11, 1959. There are many records in the literature for both sides of the Atlantic, the Indian Ocean, and the Western Pacific.
97. *Alutera scripta* (Osbeck)—longtail filefish. Shore. Reported from all seas but the Eastern Pacific by Smith (1949:462). Snodgrass and Heller (1905:410) list it from the west coast of Mexico as well as from some of the offshore islands.

Family Ceratiidae

98. *Cryptopsaras couesi* Gill. Bathypelagic. This and the following species of this family are listed from the distributional table provided by Bertelsen (1951:222) in his excellent treatise on the family based on the material from the various "Dana" expeditions.
99. *Melanocetus johnsoni* Günther. Bathypelagic. Worldwide according to Bertelsen (1951:222).
100. *Himantolophus groenlandicus* Reinhardt. Bathypelagic. Worldwide according to Bertelsen (1951:222).
101. *Ceratias holboelli* Kröyer. Bathypelagic. Worldwide according to Bertelsen (1951: 222).
102. *Microlophichthys microlophus* (Regan). Bathypelagic. Worldwide according to Bertelsen (1951:222).
103. *Chaenophyrne parviconus* Regan and Trewavas. Bathypelagic. Worldwide according to Bertelsen (1951:222).
104. *Caulophyrne jordani* Goode and Bean. Bathypelagic. Worldwide according to Bertelsen (1951:222).
105. *Edriolychnus schmidti* Regan. Bathypelagic. Worldwide according to Bertelsen (1951:222).
106. *Pentherichthys atratus* (Regan and Trewavas). Bathypelagic. Worldwide according to Bertelsen (1951:222).
107. *Dolopichthys longicornus* Parr. Bathypelagic. Worldwide according to Bertelsen (1951:222).

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Literature Cited

Ahlstrom, E. H., and R. C. Counts. 1958. Development and Distribution of *Vinciguerria lucetia* and related species in the Eastern Pacific. *Fishery Bull., U. S. Fish and Wildl. Serv., 58(139):363–416, 29 figs.*

Beebe, W., and J. Crane. 1937. Deep-sea fishes of the Bermuda oceanographic expeditions. Family Nemichthyidae. *Zoologica, 22(27):349–83, 22 figs.*

Beebe, W., and M. Vander Pyle. 1944. Eastern Pacific expeditions of the New York Zoological Society XXXIII. Pacific Myctophidae (fishes). *Zoologica, 29(9):59–95, 25 figs.*

Berry, F. H. 1959. Young jack crevalles (*Caranx* species) of the southeastern Atlantic coast of the United States. *Fishery Bull., U. S. Fish and Wildl. Serv. 59(152):417–535, 98 figs.*

Bertelsen, E. 1951. The ceratioid fishes. *Dana-Report No. 39: 276 pp., 141 figs.*

Bigelow, H. B., and W. C. Schroeder. 1948. Sharks, *In* Fishes of the Western North Atlantic, Part I. *Sears Foundation, Bingham Oceanographic Lab., New Haven:59–576, figs. 6–106.*

Bigelow, H. B., and W. C. Schroeder. 1954. Fishes of the Western North Atlantic, part II. Sawfishes, guitarfishes, skates, rays, chimaeroids. *Sears Foundation, Bingham Oceanographic Lab., New Haven: xv + 588 pp., 127 figs.*

Bigelow, H. B., W. C. Schroeder, and S. Springer. 1953. New and little known sharks

from the Atlantic and from the Gulf of Mexico. *Bull. Mus. Comp. Zool., 109(3):213–76, 10 figs.*

BOLIN, R. L. 1959. Iniomi (Myctophidae). *Report on the Scientific Results of the "Michael Sars" North Atlantic Deep-sea Exped. 1910, 4, part 2, (7):1–45, 7 figs.*

BRIGGS, J. C. 1952. Systematic notes on the oceanic fishes of the genus *Lophotus*. COPEIA, *1952 (3):206–7, 1 fig.*

BULLIS, H. R., AND F. J. MATHER. 1956. Tunas of the genus *Thunnus* of the northern Caribbean. *Amer. Mus. Nov., No. 1765:1–12, 3 figs.*

CLARK, E. 1949. Notes on some Hawaiian Plectognath fishes, including a key to the species. *Amer. Mus. Nov., (1397):1–22, 9 figs.*

EGE, V. 1954. The genus *Stomias* Cuv., taxonomy and bio-geography. *Dana Report No. 5:58 pp., 12 figs., 1 pl.*

EKMAN, S. 1953. Zoogeography of the sea. *Sidgwick and Jackson, London: xiv + 417 pp., 121 figs.*

FOWLER, H. W. 1936. The marine fishes of West Africa. *Bull. Amer. Mus. Nat. Hist. 70:1–1493 pp., 565 figs.*

FOWLER, H. W. 1941. A list of fishes known from the coast of Brazil. *Arquivos de Zoologica, Estado de São Paulo, 3(6):115–84.*

FOWLER, H. W. 1944. The results of the fifth George Vanderbilt expedition (1941). Fishes. *Acad. Nat. Sci., Phila. Monograph No. 6:57–529, 268 fgs., 20 pls.*

FOWLER, H. W. 1949. The fishes of Oceania—supplement 3. *Mem. Bishop Mus., 12(2):37–186.*

FRASER-BRUNNER, A. 1949. A classification of the fishes of the family Myctophidae. *Proc. Zool. Soc. London, 118:1019–106, 14 fgs., 1 pl.*

FRASER-BRUNNER, A. 1950. The fishes of the family Scombridae. *Ann. Mag. Nat. Hist., Ser. 12, 3(26):131–63, 35 figs.*

FRASER-BRUNNER, A. 1951. The ocean sunfishes (family Molidae). *Bull. British Mus. (Nat. Hist.):89–121, 18 figs.*

GIBBS, R. H., AND B. B. COLLETT. 1959. On the identification, distribution and biology of the dolphins, *Coryphaena hippurus* and *C. equiselis*. *Bull. Mar. Sci. Gulf and Carib., 9(2):117–52, 18 figs.*

GREY, M. 1955. The fishes of the genus *Tetragonurus* Risso. *Dana-Report No. 41:1–75, 16 figs.*

GREY, M. 1956. The distribution of fishes found below a depth of 2000 meters. *Fieldiana: Zoology, 36(2):75–337.*

HAIG, J. 1955. Fishes killed by the 1950 eruption of Mauna Loa III. Sternoptychidae. *Pacific Science, 9:318–23.*

HERRE, A. W. 1953. Check list of Philippine fishes. *U. S. Fish and Wildl. Serv., Res. Rept. No. 20:1–977.*

HUBBS, C. L., AND W. I. FOLLETT. 1953. Information based on a manuscript list of the fishes of California. Fourteenth unpublished edition: 1–65.

JORDAN, D. S., B. W. EVERMANN, AND H. W. CLARK. 1930. Check list of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Colombia. *Rept. U. S. Comm. Fish. for 1928, part 2: 650 pp.*

KAMOHARA, T. 1952. Revised descriptions of the offshore bottomfishes of Prov. Tosa, Shikoku, Japan. *Rep. Kochi Univ., Nat. Sci., No. 3:1–122, 100 figs.*

KUMADA, T. 1937. Marine fishes of the Pacific Coast of Mexico. Nissan Fisheries Institute and Co., Ltd., Odawara, Japan, pp. 1–75, 102 pls.

MANN, F. G. 1954. La vida de los peces en aguas Chilenas. Universidad de Chile, Santiago: *342 pp., illus.*

MAUL, G. E. 1956. Monografia dos peixes do museu municipal do Funchal, ordem Discocephali. *Biol. Mus. Mun. Funchal, 9(23):5–75, 5 figs.*

MEAD, G. W. 1957. On the bramid fishes of the Gulf of Mexico. *Zoologica, 42:51–61, 3 pls.*

MOHR, E. 1937. Revision der Centriscidae (Acanthopterygii Centrisciformes). *Dana-Report No. 13; 69 pp., 33 figs., 2 pls.*

MUNRO, I. S. R. 1955. The marine and fresh water fishes of Ceylon. *Dept. External Affairs, Canberra: xvi + 349 pp., 19 figs., 56 pls.*

NORMAN, J. R. 1930. Oceanic fishes and flatfishes collected in 1925–1937. *Discovery Reports, 2:261–370, 47 figs., 1 pl.*

PARR, A. E. 1946. The Macrouridae of the western North Atlantic and Central American seas. *Bull. Bingham Oceanogr. Coll., 10, Art. 1: 99 pp., 28 figs.*

RICKER, K. E. 1959. Mexican shore and pelagic fishes collected from Acapulco to Cape San Lucas during the 1957 cruise of the "Marijean". *Mus. Contrib. Inst. Fisheries, Univ. Brit. Col., No. 3:1–18.*

RIVAS, L. R. 1951. A preliminary review of the western North Atlantic fishes of the family Scombridae. *Bull. Mar. Sci. Gulf and Carib., 1(3):209–30.*

ROSENBLATT, R. H., AND W. J. BALDWIN. 1958. A review of the Eastern Pacific sharks of the genus *Carcharchinus*, with a redescription of *C. malpeloensis* Fowler and California records of *C. remotus* (Duméril). *Calif. Fish and Game, 44(2):137–59, 19 figs.*

SMITH, J. L. B. 1949. The sea fishes of southern Africa. *Central News Agency, Cape Town: xvi + 550 pp., 1100 figs., 103 pls.*

SMITH, J. L. B. 1958. Rare fishes from South Africa. *South African Jour. Sci., December, 1958: 319–23, 2 figs.*

SNODGRASS, R. E., AND E. HELLER. 1905. Papers from the Hopkins-Stanford Galapagos Expedition, 1898–1899. XVII. Shore fishes of the Revillagigedo, Clipperton, Cocos and Galapagos Islands. *Proc. Wash. Acad. Sci., 6:333–427.*

DE SYLVA, D. P. H., H. B. STEARNS, AND D. C. TABB. 1956. Populations of the black mullet (*Mugil cephalus* L.) in Florida. *Fla. State Bd. Conserv., Tech. Ser., No. 19:7–45, 10 figs.*

TORTONESE, E. 1950. A note on the hammerhead shark, *Sphyrna tudes* Val., after a study of the types. *Ann. Mag. Nat. Hist., Ser. 12, 3:1030–33.*

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Length and Weight of Ancient Freshwater Drum, *Aplodinotus grunniens,* Calculated from Otoliths Found in Indian Middens

Arthur Witt, Jr.[1]

THE sizes of fishes during aboriginal times are poorly known. Such information, however, is of value to both ichthyologists and fishery biologists. In order to determine the length and weight of fishes during aboriginal times a skeletal structure must be preserved, relatively intact, and it must be possible to relate the size of this structure to the size of the same structure and to the length or weight of present day fishes.

Numerous remains of fishes are found in the middens of American Indians (Rostlund, 1952; Taylor, 1955; Parmalee, 1956) and among these are the sacculiths of the freshwater drum, *Aplodinotus grunniens* Rafinesque. This paper will discuss the relationships between length and weight of otoliths and length and weight of the freshwater drum. With these relationships established, the size of aboriginal freshwater drum will be estimated from the otoliths found in Indian middens.

Materials

In July, 1957, freshwater drum were collected from the Mississippi River at Hannibal, Missouri, with the aid of commercial fishermen: Jim Stone and Orville Lewallen. For two years previous to this date they collected otoliths only from fish that weighed more than two pounds. A total of 172 fish was collected with a length range of 225–703 mm. (8.9–27.7 in.) and a weight range of 129–5443 g. (0.3–12.0 lbs.). Total length in mm., weight in g., sex, scales and the otoliths were obtained for each fish. The otoliths were air dried for a month, weighed to the milligram and their length measured to the tenth of a mm. The average weights and lengths of both otoliths for each fish were used to develop the following relationships, unless one otolith was shattered during removal from the skull of the fish.

Ancient otoliths were obtained from four aboriginal Indian sites in the midwest and from one in the south. Fifty-nine otoliths from the Modoc Rock Shelter in Randolph Co., Illinois, were borrowed from the Illinois State Museum. This shelter is a relatively dry sandstone cave that overlooks the Mississippi River Valley (Fowler and Winters, 1956). The otoliths were found in different levels within the shelter and have been dated by means of radioactive carbon. The majority of them are estimated to date from 3600–3700 B.C., a few of 6000 B.C., and one from 7000 B.C. (Parmalee, *in litt.*). Considering the antiquity of these otoliths they are preserved extremely well. They are entire, some even with serrations along their sharp margins, and are very hard as contrasted to the chalky and eroded appearance of those from a later date, *i.e.*, the Clear Lake Site. In contrast to all otoliths from other sites these are colored tan, brown or black.

The museum also provided 120 otoliths from the Clear Lake Site along the Illinois River in Tazewell Co., Illinois. These otoliths are associated with the Late Woodland (Hopewellian) and Middle Mississippi Cultures and are estimated to date from 1000–1400 A.D. (Parmalee, *in litt.*). This is an exposed site; consequently, a majority of the otoliths are severely eroded about their margins, chipped, and are rough and chalky in appearance.

Ninety-three otoliths were obtained from the Science Museum, St. Paul, Minnesota. These came from the Lee Mill Cave which is a limestone cave along the Mississippi River in Dakota Co., Minnesota (Taylor, 1955). An area adjacent to the site from which the otoliths were taken was dated by means of radioactive carbon and Taylor (*in litt.*) estimates that the otoliths date from before 700 A.D. These are in good condition; they are hard and the margins are entire and sharp.

Two hundred and sixty otoliths were obtained from the University of Michigan Museum of Anthropology. These came from the Dustin Green Point Site (2-1) at the fork of the Tittabawasee and Shiawassee Rivers in Saginaw Co., Michigan, and are estimated to date from 950–1600 A.D. (Griffin, *in litt.*). They are in poor condition, the edges are

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation and University of Missouri Cooperating.

severely eroded and they are chalky in appearance.

Ten otoliths from the Etowah Site in Bartow Co., Georgia, were obtained from the Illinois State Museum. These are estimated to date from 1200–1500 A.D. (Parmalee, *in litt.*) and are in good condition, being entire and smooth.

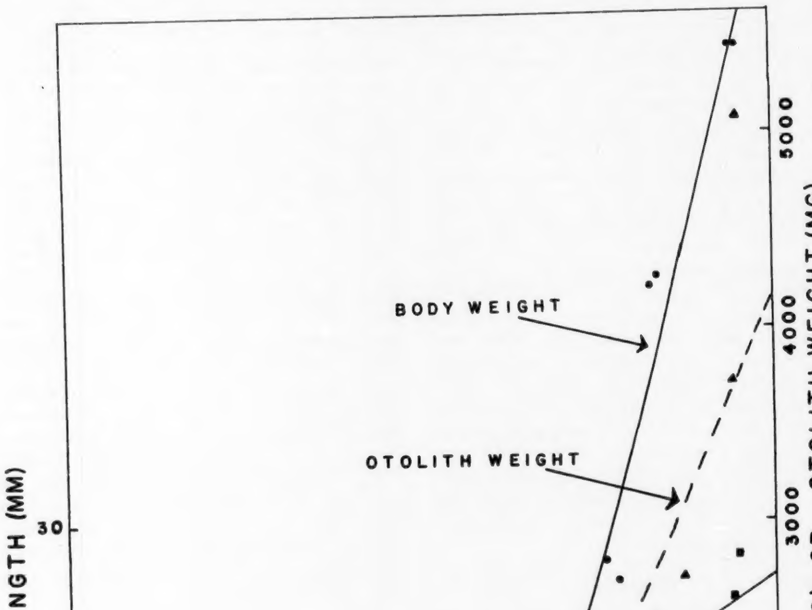

Fig. 1.—Relationships between otolith weight and body length; otolith length and body length; body length and weight in the freshwater drum, *Aplodinotus grunniens*.

Results

The recent freshwater drum were arranged into 10 mm., class intervals of length and the average lengths and corresponding average otolith weights were determined for each interval. A curve was fitted to these data (Fig. 1) and the relationship between otolith weight and body length of the drum can be described by the expression: $Log\ OW = -3.1286 + 2.3534\ Log\ BL$; where OW = otolith weight and BL = body length.

Similarly, average body lengths and corresponding average otolith lengths were determined (Fig. 1) and this relationship can be described by: $BL = -70.3253 + 29.8974\ OL$; where BL = body length and OL = otolith length.

Either of these relationships can be used to estimate the length of freshwater drum when either otolith length or weight is known; however, I have used the latter relationship because for large fish there is less variation in otolith length than there is in otolith weight. Calculated lengths of the largest recent freshwater drum, based on the former relationship, are 14 percent greater than actual lengths, and are 10 percent greater than actual lengths when based on the latter. These differences approach zero percent for medium and small sized fish.

Templeman and Squires (1956) have shown that old slow growing haddock have heavier and larger otoliths than do young fast growing fish of the same length. I have inconclusive evidence that this may also be true for the freshwater drum, and it is possible that this, along with inadequate numbers of large fish may be responsible for the larger variation in otolith weight for larger drum.

The body length-weight relationship (Fig. 1) was calculated for the recent freshwater drum and can be described by: $Log\ W = -5.6127 + 3.2944\ Log\ L$.

With the above relationships established, weights or lengths of otoliths from aboriginal drum can be substituted into the proper equation and the calculated length of the fish obtained. This length can be substituted into the length-weight equation and the weight of the fish determined.

The sizes of recent and aboriginal freshwater drum can be compared in two ways. First, a length frequency distribution of the ololiths from recent and aboriginal fish is indicative of the relative size and numbers of fish in each collection (Fig. 2). (Those from

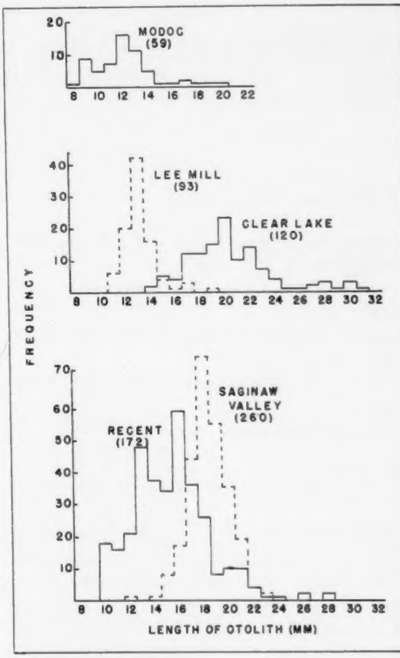

Fig. 2.—Length frequency distribution of ancient and recent otoliths from freshwater drum, *Aplodinotus grunniens*.

the Etowah Site are omitted because of small numbers.) Secondly, the calculated total lengths and weights of the aboriginal drum and actual lengths and weights of recent fish are compared in Table I. It should be remembered that sizes of fish based on measurements of eroded otoliths will be underestimates of their actual lengths or weights. Thus, the calculated lengths and weights in Table I will be conservative.

Discussion

In general the ancient freshwater drum decrease in size and numbers with an increase in the antiquity of the sample (Fig. 2, Table I). The largest fish and the greatest number of large fish came from the Clear Lake collection: the largest was 865 mm. (34.1 in.) long and weighed 11570 g. (25.5 lbs.); the mean length of these fish was 552 mm. (21.7 in.). A comparison of the freshwater drum from Clear Lake, Saginaw Valley and the Etowah Site show that their mean lengths and length ranges are amazingly similar, except for the few unusually large

TABLE I

CALCULATED TOTAL LENGTH IN MILLIMETERS (INCHES) AND WEIGHT IN GRAMS (POUNDS) OF ANCIENT FRESHWATER DRUM, *Aplodinotus grunniens*.[1]

Location	Date	Number	Length		Weight	
			Range	Mean	Range	Mean
Modoc Rock Shelter, Randolph Co., Ill.	7000–3600 B.C.	59	196–537 (7.1–21.1)	306 (12.0)	87–2404 (0.2–5.3)	377 (0.8)
Lee Mill Cave, Dakota Co., Minn.	Before 700 A.D.	93	265–498 (10.4–19.6)	336 (13.2)	235–1875 (0.5–4.1)	513 (1.1)
Clear Lake, Tazewell Co., Ill.	1000–1400 A.D.	120	372–865 (14.6–34.1)	552 (21.7)	717–11570 (1.6–25.5)	2633 (5.8)
Saginaw Valley, Saginaw Co., Mich.	950–1600 A.D.	260	312–641 (12.3–25.2)	492 (19.4)	402–4308 (0.9–9.5)	1802 (4.0)
Etowah Site, Bartow Co., Ga.	1200–1500 A.D.	10	420–620 (16.5–24.4)	507 (20.0)	1070–3860 (2.4–8.5)	1989 (4.4)
Recent, Marion Co., Mo.	1957	172	225–703 (8.9–27.7)	396 (15.6)	129–5443 (0.3–12.0)	1056 (2.3)

[1] Actual lengths and weights are given for recent fish.

fish from Clear Lake. The fish from these three sites date from relatively the same time, 950 to 1600 A.D. It is not known whether this similarity in size is a reflection of uniform environmental conditions, selective aboriginal fishing methods, or pure chance.

The freshwater drum from the Lee Mill Cave, which are dated to "before 700 A.D.", are smaller in size and have a mean length of 336 mm. (13.2 in.). Finally, the smallest fish with a mean length of 306 mm. (12.0 in.) occurred in the Modoc Rock Shelter and are dated 7000 B. C.

The mean lengths of present day freshwater drum, in the vicinity of these aboriginal sites, are generally smaller than the mean lengths of fish from the aboriginal sites. The recent collection of freshwater drum from the Mississippi River had a mean length of 396 mm. (15.6 in.) but this length is biased due to the selection of only large fish for over a period of two years. A more realistic average length for freshwater drum of the Mississippi River was reported by Barnickol and Starrett (1951): 269 mm. (10.6 in.) for fish collected between Dubuque, Iowa, and the mouth of the Missouri River. This is in the same general region of Clear Lake and the Modoc Rock Shelter.

The present day average length of the freshwater drum in the vicinity of the Lee Mill Cave can be computed from Butler and Smith (1950). Their work covered a section of the Mississippi River between Lake Pepin and Muscatine, Iowa, and they reported an average length of 275 mm. (10.8 in.) which is smaller than that of the Lee Mill Cave ancient fish. The freshwater drum from Lake Erie (Van Oosten, 1938) were calculated to average only 252 mm. (9.9 in.) which is smaller than those from Saginaw Valley. There are no recent data to compare with the ancient freshwater drum from the Etowah Site.

The reasons for a general decrease in the size of the freshwater drum with the increased antiquity of the sample are open to speculation. Fowler and Winters (1956) discussed the climatic and environmental variation that occurred at the Modoc Rock Shelter during its history. They point out that this shelter was occupied by man at about 7900 B.C. when the Mankato Stage of the Wisconsin Glaciation was in Minnesota and Northern Wisconsin. Glacial Lake Chicago and the melt water from the glacier in Minnesota drained through the Mississippi River Valley past the Modoc Rock Shelter. This resulted in the river being much larger and colder than it is today. Following this there was the transition to the Thermal Maximum (4000–3000 B.C.) and the drum otoliths from the Modoc Rock Shelter are contemporary with this transition period. It is therefore logical to assume that the river waters would be cooler and less fertile than they are today and the fish smaller in size.

There seems to be little reason for doubting the ability of the aboriginal Indian to

take large fish. Rostlund (1955) discusses the variety of fishing methods used by the aboriginal Indians. However, the Archaic Indians that inhabited the Modoc Shelter probably fished only with a wooden spear. If this is correct, the small size of drum from this period would not be explained through selective fishing.

The climatic conditions which existed at the time the aboriginal Indians collected the Clear Lake, Lee Mill Cave, Green Point Site and Etowah Site freshwater drum were similar to those of the present day. In those pre-Columbian and immediate post-Columbian times the bottom-land lakes and rivers in the Mississippi Valley must have supplied the freshwater drum with an excellent source of molluscan foods, which would be reflected in good growth.

The fishing methods employed by the aboriginals at this time had improved in effectiveness and would allow the capture of large and small fishes. Rostland (1955) indicates that such fishing devices as seines, gillnets, hand nets, weirs, hooks, harpoons, leisters and the spear were used by various Indian tribes in the eastern half of the United States during pre-Columbian times.

The relatively small size of recent freshwater drum in the Mississippi River is probably due to a combination of factors: alteration of the environment and food supply by the drainage of bottom land lakes; construction of navigation dams with resultant silting; water pollution. Cropping by the sport and commercial fisheries would also be important.

The maximum size of *Aplodinotus grunniens* is reported to be 4 feet in length and 60 pounds (Jordan and Evermann, 1898). Hubbs (*in litt.*) and Hubbs and Lagler (1958) estimated that this species may have attained a weight of about 200 pounds during primordial times. This was an estimate based upon lower pharyngeal arches taken from middens in the Gulf States and compared with pharyngeal arches from a recent 20 pound specimen. A direct relation was assumed for length and a cube relation for weight. One would reason that out of nearly 500 otoliths from aboriginal times, which were examined in this work, a few of them would have represented unusually large specimens of this species. This, however, was not the case and leads me to believe that the maximum size of this species is probably well under 100 pounds.

Acknowledgments.—I wish to thank the following men who supplied me with ancient freshwater drum otoliths: Dr. Paul W. Parmalee, Dr. James B. Griffin and Mr. Philip S. Taylor; Mr. James Stone and Mr. Orville Lewallen helped me to collect fish from the Mississippi River. I also wish to thank Dr. Carl L. Hubbs for information about his studies on the freshwater drum.

Literature Cited

BARNICKOL, PAUL G. AND WILLIAM C. STARRETT. 1951. Commercial and sport fishes of the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa. *Bull. Ill. Nat. Hist. Surv. Div. 25(5):267–350.*

BUTLER, ROBERT LEE AND LLOYD L. SMITH, JR. 1950. The age and rate of growth of the sheepshead, *Aplodinotus grunniens* Rafinesque, in the upper Mississippi River navigation pools. *Trans. Amer. Fish. Soc. 79 (1949): 43–54.*

FOWLER, MELVIN L. AND HOWARD WINTERS. 1956. Modoc Rock Shelter preliminary report. *Ill. State Mus., Report Invest. 4:1–58, multilithed.*

HUBBS, CARL L. AND KARL F. LAGLER. 1958. Fishes of the Great Lakes Region, revised edition. *Bull. Cranbrook Inst. Sci. No. 26:(xiv) + 214 pp.*

PARMALEE, PAUL W. 1956. (In) Modoc Rock Shelter preliminary report by Melvin L. Fowler and Howard Winters. *Ill. State Mus. Report Invest. 4:1–58, multilithed.*

ROSTLUND, ERHARD. 1952. Freshwater fish and fishing in native North America. *Univ. Calif. Publ. Geog. 9:*(x) + *314 pp.*

TAYLOR, PHILIP S. 1955. The identification of bone fragments from the Lee Mill Cave Site. *Proc. Minn. Acad. Sci. 23:29–34.*

TEMPLEMAN, WILFRED AND H. J. SQUIRES. 1956. Relationship of otolith lengths and weights in the haddock *Melanogrammus aeglefinus* (L.) to the rate and growth of the fish. *Jour. Fish. Res. Bd. Canada, 13(4):467–487.*

VAN OOSTEN, JOHN. 1938. The age and growth of the Lake Erie sheepshead, *Aplodinotus grunniens* Rafinesque. *Pap. Mich. Acad. Sci. Arts, and Lett. 23(1937):651–658.*

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Communal Spawning of the Glassy Darter *Etheostoma vitreum* (Cope)

Howard E. Winn and Anthony R. Picciolo

THIS paper describes and discusses an unusual type of reproductive behavior that is carried out by the glassy darter, *Etheostoma vitreum*. Individuals of this fish aggregate in large numbers on small rocks where the eggs are deposited. Group spawning habits are known for fishes where the individuals occur in large aggregations and the eggs are either scattered over the substrate or released in midwater. However, it is unusual for a demersal fish, with the above habits, to restrict its egg deposition to a small object where the eggs adhere. Furthermore, this communal spawning differs from the normal territorial organization for the darters, Etheostomatinae—Percidae (Winn, 1958a and b). The only other known species exhibiting a social schooling organization is *Percina caprodes*, which spawns in lakes over large areas of sand.

The present study revealed a type of communal spawning that is unique for darters as well as for other fishes. *Etheostoma vitreum* is normally found over a shifting fine sand substrate, to which they exhibit many morphological adaptations. They leave this habitat for a period of three or four weeks to spawn communally on rocks and logs. During this time aggressive behavior is limited but not completely absent. It is proposed that this represents the most specialized behavior that has recently evolved from the highly complex spawning habits known for darters.

Etheostoma vitreum is found in the coastal freshwater streams of the Eastern United States from Maryland to North Carolina. It exhibits a series of morphological adaptations to the sand habitat as follows: large pectoral fins, translucent and very slender body, ventral region mostly scaleless, and dorsally located eyes. The males become very dark in the breeding season and the females' coloration darkens to a lesser degree.

Materials and Methods

A large population of a thousand or more individuals was studied in Western Branch Creek where it crosses state highway 202 about 2.5 miles southeast of Largo in Prince Georges County, Maryland. Observations were made through a glass bottomed box for continuous periods, some observations ranging from 15 minutes. The area upstream from the bridge consisted of a large pool with many rocks on the west bank which supported the bridge. Just above this pool there was a concrete spillway with a U.S.G.S. stream station beside it. The current was very slow above the spillway, and the bottom was mostly of mud. For about one quarter of a mile downstream from the spillway some mud bottom was found but gravel and fine shifting sand areas were also present. The current was slow to very rapid. This part of the stream flowed through a wood and its banks were usually three or more feet high. Rocks occurred from the spillway to the bridge but only logs were found downstream. The water usually was silt-laden and observations could be made only after several days of drought. The stream was from 15 to 20 feet wide.

Observations were made also on fish brought into the laboratory during the normal reproductive season. Ripe males and females (usually two pairs) were placed in 50 gallon (36 x 18 x 18 in.) tanks with various types and distributions of fine sands on the bottom. The experiments were replicated 13 times. Eggs were deposited somewhat normally only once and this was in a single mass in the corner of the aquarium on glass, cement and slate. Eggs were found frequently scattered individually on the bottom of the tank and covered with fungus. Successful spawning was obtained in an oval plexiglas tank in which a current was produced by a paddle wheel (Fig. 1). A ⅓ horse power motor drove a 48 to 1 speed reducer. Attached to the reducer was a 4 step pulley which was connected by a belt to a graded series of pulleys attached to the shaft of the paddle wheel. This created a graded series of currents. Sand and rocks were placed in the ends and the straight section opposite the paddle wheel. The illumination was diffuse natural daylight. The pH was maintained between 7.0 to 7.1.

Spawning Season and Habitat

During 1956, most of the females but none of the males were spent by April 22 in the field. In 1957, spawning started about the

middle of March and ended about the middle of April. In the spring of 1958, the data for the spawning season are as follows: March 4, 5 fish caught, male and female, none ripe at 5°C; March 30, 3 females caught and not ripe at 6.5°C; April 10, 20 fish caught, males running milt and females almost ready to spawn at 8°C; April 14, males ripe and females very distended but none spent and no eggs found at 12°C; April 16, a few eggs found at 13°C; April 18 and 19, many eggs added to those first seen, a few females spent at 15°C. No further observations were made. During the spring of 1959, observations and collections were upset because of bridge construction, but it was determined that eggs were laid first between March 21 and April 3 and that all fish were spent by April 24.

The data above and other general information show that the spawning season is usually only three to four weeks long and that egg deposition usually starts about the middle of March and extends into April. Egg deposition began about April 14 to 16 in 1958 which by comparison with the previous two years had an extremely late and cold spring. The spawning season may have been shortened in 1958 because of a rapid rise in temperature after the middle of April. After the spawning season, the darters scatter into the areas of fine sand. They flee or rapidly bury themselves in the sand when approached by strange objects. Some individuals were caught in the late summer and early fall just below the concrete spillway. In the late fall and winter they were downstream in deeper water and were inactive. Usually in early March (early April in 1958), they became concentrated on the fine sand on or near the egg laying sites. Spawning began when the temperature rose above 10° to 12°C and ceased before it reached 16° to 18°C. Spawning in the laboratory in April of 1958 was carried out at temperatures of 10° to 19°C.

The description of the various egg sites in the field, first found in 1958, is as follows: one site consisted of a rock covered with 30,000 to 50,000 eggs and over 50 spawning fish were seen on it (Figs. 2A and 3). The eggs were concentrated on two surfaces headed into the current, under the front edge and on the top. The rock was about 12 inches in diameter and 6 to 8 inches in height. One rock behind this and four in front contained fewer eggs and individuals. All the eggs were on the surfaces that were

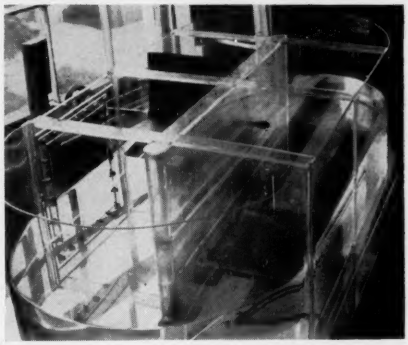

Fig. 1.—A plexiglas stream where successful spawning of the glassy darter, *Etheostoma vitreum*, took place.

facing directly into the current. These rocks with eggs were located among many other rocks just above the concrete abutment of the bridge. Ten feet downstream an area of fine stand stretched under and somewhat below the bridge. Two large batches of eggs were located on the vertical face of the spillway where the fast current was directed towards it (Fig. 2B). Fine sand patches occurred just below the spillway. Another group of glassy darters with an egg mass was found in a small hole in the horizontal face of the spillway (Fig. 2C). The tails of at least 10 individuals could be seen of which 8 or 9 were males. Finally, a patch of 1,000 to 3,000 eggs was located on the undersurface of a log, 8 to 10 inches in diameter, 12 inches above an area of fine sand (Fig. 2D).

On the basis of the field and laboratory data, the egg-site of the glassy darter is quite restricted. A hard surface must be present in a fairly rapid current. This can be a vertical, an under or a top surface. Areas of a fine shifting sand must be nearby.

Field Observations

April 16, 1958, (15 minutes).—Many glassy darters were observed in the afternoon in the area of the concrete spillway. Two males were on the lip of the spillway (Fig. 2B). The current held the fish against the vertical face of the spillway. Both males were very dark and pushed at each other as they moved about. These encounters were very brief because of the strong current. The large male once dashed vigorously at the smaller one. A large female came up the vertical face of the concrete and both males immediately

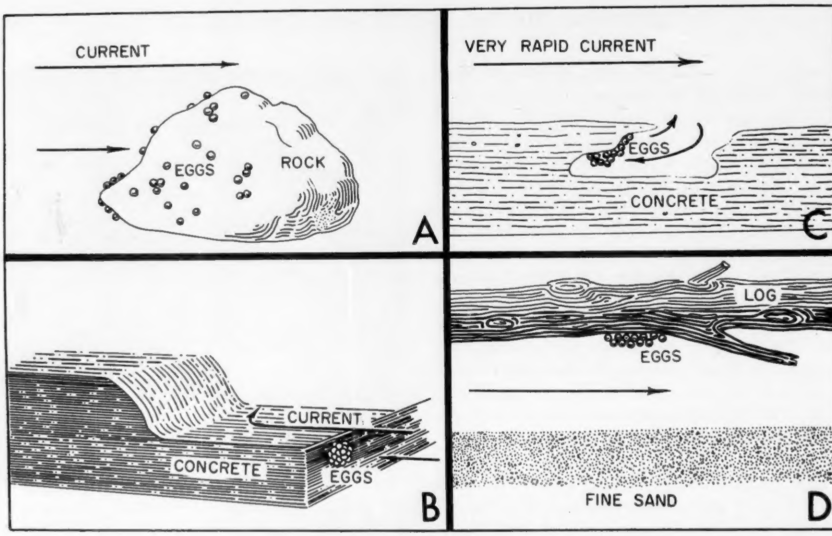

Fig. 2—Types of egg deposition sites of the glassy darter, *Etheostoma vitreum*, in relation to the current.

Fig. 3—Photograph of the central spawning rock covered with egg clusters of *Etheostoma vitreum* found in Western Branch Creek.

moved jerkily beside her near a small patch of eggs (see Fig. 2B). The female swam over the eggs occasionally and both sexes vibrated briefly at this point. Vibrating consisted of synchronous and rapid trembling of the two sexes closely adjusted adjacent to or in contact with one another in various positions. The female had to circle around in order to keep going over the eggs because of the strong current. The two males followed her with the larger one occasionally pushing at the smaller one. However, the large male directed most of his activity toward keeping beside the female. There were other female glassy darters, their abdomens distended with eggs, on the lower part of the vertical face and on the sand.

(3:00–3:15 PM).—One female and two males occasionally moved over the egg patch. Brief vibrations were made by the female with both males beside her. The female moved away and the large male chased the small male. The female returned to the egg patch and the males came in beside her. She moved off 12 inches and circled slowly back around the eggs with only the large male in attendance. The small male came in and all three vibrated briefly over the eggs. Eggs presumably were laid and fertilized at this time. One male came up and attached to the glass of the observation bucket.

April 18.—Similar behavior was noted in the same place as on April 16. Five dark males were at the area, pushing at each other. The patch of eggs had increased greatly in size, and there was a smaller discrete patch nearby. Another group of spawning darters was located in the afternoon on rocks 12 to 18 inches in diameter. Six males and two females were on one rock with eggs. The rock in front was the ultimate in the communal spawning of darters (Fig. 2A and Fig. 3 and previous egg-site description). There were a minimum of 50 darters on the sides and top of the rock which had 30,000 to 50,000 eggs on it on April 18, 1958. It was impossible to count the number of individuals or eggs accurately. Four other rocks directly in front of this central spawning rock had many eggs and approximately 15 to 35 darters on each. There were one or two other rocks with less than 10 individuals on them. Other observations on the central rock with most of the darters and eggs were as follows. Ten males were grouped around a female. She moved and the males followed pushing at each other. Several individuals of *Notropis cornutus* passed by the rock but did not molest the eggs. Individuals of *Etheostoma nigrum* and *Percina pelata* were seen in the area but were never observed to eat eggs. Various small groups of glassy darters stopped and vibrated simultaneously every once in awhile. Presumably this was when an egg or eggs were laid. Various females moved around on the rock followed by several males. It was very difficult to describe the spawning activities and one individual could not even be visually followed for any length of time because of the large numbers of fish and poor observational conditions.

Laboratory Observations

April 10, 1958.—Three large ripe males and three large ripe females were placed in the plexiglas stream which already held one "inactive" male and one female. Rocks were placed at various points in the stream on gravel and sand. Currents varied from 0.2 to 0.7 ft. per sec. at the face of a rock where eggs were laid in the laboratory stream.

April 11, 1958 (30 minutes).—Sexual activity had commenced. A male followed a female up close to the middle rock and then he left to stay at an area (X) near the front and side of the middle rock. A second male came to area X and both males pushed at each other sideways on the sand and up the front face of the rock by X. The first male swam up to the female in a jerky fashion, touched her with his snout and then returned to area X. Sometimes the female also went to area X and then left. Several times another male came to area X which resulted in either the first male dashing at him so that he left or the new male remained and they pushed at each other sideways as previously described. The males moved over the face of the rock at area X in all positions (vertical, sideways, etc.). The water current held the fish firmly against the rock. All the above activities, centered around area X, continued most of the day.

April 12, 1958 (25 minutes).—A male by area X was light-colored and at times almost black. There was little activity on this day.

April 13, 1958.—A large patch of eggs was on the vertical face of the rock directed into the flow of current at area X. These were not observed the previous day. A sample was examined and found to contain eyed embryos.

April 14, 1958 (40 minutes).—Earlier in the day the eggs were observed to be present but no male was beside them. Later three males were by the eggs pushing sideways at

each other over the face of the rock. Occasionally one male would nip at another one. There were an estimated 90 eggs in the batch.

April 15, 1958 (1:45–2:30 PM).—There were two males upsidedown on the under portion at the back of area X and pushing at each other. A female approached and one male nipped at and chased the other male away. He went out to the female. The female left the area. Several males moved back and forth over the rock. Two ripe females were upstream from the rock. The male at area X went up above the females and drifted back down on a female as though this would drive her toward the rock. A male moved over the eggs several times with a slightly vibrating motion.

(6:30–6:50 PM).—Three almost black males were near area X. One chased another away. One male vibrated beside a female on the gravel several inches upstream. One male at X nipped at a male which approached and then left. All the males in the area of the rock moved about actively. A male at X moved over the eggs several times. Intermittently he pushed at males, followed females for several inches and moved over the front and top of the rock. A female went to the vertical face of rock X and the dark male moved beside her. Two other males immediately came in beside them and there was considerable gentle pushing and nudging between the males. The female then moved away from the rock. Two males pushed at each other at X and the dark male, usually at X, weakly chased the other a few inches away. Occasionally he nipped at an intruder male. When a female was on the rock he usually did not chase other males that also came in beside the female. Similar activities were recorded for another 15 minutes.

April 16, 1958 (9:00–9:15 AM).—All specimens were removed from the tank except four males and two ripe females. The usual activities were observed as: male followed female over rocks with other males; occasionally male at X nudged other males in area; and male at X went over batch of eggs and front of rocks.

(9:15–9:35 AM).—A semi-dark male was at X and a female on the face of X rock. New eggs had been added to the patch since the previous night. The female was moving back and forth over the patch of eggs with a male beside her. The female vibrated and the male vibrated beside her at which time it appeared as though one egg was laid against the previously existing patch of eggs. One of the male's large pectoral fins was kept over the female as they moved back and forth. Sometimes the male was half on top of the female. Each time the female stopped, the male nudged her sides. She moved to the top of the rocks; the male followed, pushing against her side. Vibrations and egg laying occurred only when the female's urogenital papilla was in contact with the previously laid eggs. The female went to X and so did the male. She left the area and the male moved over the eggs in between excursions over and around the rock. A large patch of eggs deposited since the previous night was on the front face of the rock. The usual activities of excursions over and around rock, over the eggs, nudging between males, and following of females were observed in the last ten minutes. When spawning activities were particularly intense, the male became black all over whereas at other times he was black on the lower half of the body and a brown color above, or lighter all over the body.

(12:54–1:00 and 7:00–7:05 PM).—All of the above activities were observed again. It still appeared as though one egg was deposited at a time until a patch was laid which took as long as a day or more due to the difficulties of adjustment in the current and the mass pushing of the group. They continued these activities when there was barely enough daylight to observe them. Two ripe females were added to the tank.

April 17, 1958.—Some of the eggs had hatched. Many new eggs were added since last night. Two discrete patches of eggs were separated by a distance of one and one-half inches.

April 18, 1958.—The previously two discrete patches of eggs were now united into one large patch. The females were all spent.

Discussion

The communal spawning of the glassy darter represents a unique type of reproductive behavior among the freshwater fishes of North America. A large group of individuals move over a small area that is in the path of the current. A small spawning group seems to attract other individuals of both sexes, thus leading to the formation of a large spawning aggregation. Aggressiveness, although still present to the degree of pushing between males, is reduced, especially as the number of individuals increases on a

spawning site. A large number of males may be required in the spawning act in order to insure a high percentage of fertilization because of the swift currents involved. Although territoriality is usual in the darters and many other bottom-adapted fishes, *E. vitreum* is able to reproduce successfully without a territorial system. Undisturbed mating may be a result of territoriality rather than its prime function.

The females of the glassy darter lay fewer eggs than any other known darter (work in progress by Stout and Winn). It was estimated that 100,000 eggs were laid in the stream area studied. Since observations indicate that the females lay an average of about 100 eggs for one spawning season, then a minimum of 1,000 females must be present in the one quarter mile stretch of stream with most of them concentrated just below the spillway. The bridge, rocks and spillway may represent an abnormal egg-site area for this species.

Ordinarily, eggs laid in such an exposed and concentrated condition would be eaten by the numerous suckers, minnows and darters. Thus, for selective purposes, if communal spawning were to evolve, it was necessary for this habit to occur earlier in the spring when the temperatures are low, the currents fast with high water and the water silt-laden. These cause a reduced activity of the poential egg predators and makes it physically and visually difficult for them to feed on the eggs. Thus in this case there is a reduced egg loss due to predation correlated with a small number of eggs produced by each female. Also, in order for objects such as logs and rocks to be used, some adjustment from the usual darter type of reproduction was necessary. This new habit has strong survival value in the coastal streams because of the very small number of such materials present except in slow pools where predation could be very effective upon the exposed eggs of a small fish.

There has been some doubt as to the relationship of this species of darter, which until recently was in the monotypic genus *Ioa*. On the basis of its habits, its most obvious relatives are the johnny darters (subgenus *Boleosoma*). The boleosomids have apparently developed rather specialized breeding habits among the darters (Winn, 1958b). The male selects an area under a rock or other object in April, May and June (depending on temperature) in a slow current. The females then enter under the rock and the eggs are laid individually and fertilized in an inverted position. The male guards the area against all individuals of a size that could get in under the objects used as nests. Although the behaviorial characteristics of the glassy darter are quite different from other darters, the origin of all of these can be traced to the boleosomids. It is presumed that the glassy darter has evolved from a darter with these boleosomid characteristics. If one mentally constructs a darter population whose egg-laying occurs over as well as under the rocks, reduce the aggressiveness of its members, and have spawning for the species occur earlier in the spring and in faster currents, then the communal spawning of the glassy darter will result. This darter has an egg number which is reduced from that of the johnny darter, *Etheostoma nigrum* (an average of 100 plus vs 800 plus). The johnny darters lay 5 or 6 clutches of 30 to 200 eggs in one season. The one clutch laid by the glassy darter in a shortened time represented 68 to 223 eggs in 8 specimens. It is interesting to note that the number of eggs per clutch is similar but that the number of clutches has been reduced to one. The glassy darter exhibits morphological adaptations to a fine shifting sand environment. This is only a refinement of the beginnings of these adaptations in the johnny darter which also tends to stay over sand areas. Other similarities between the two darters are as follows: the sexes are beside each other in the spawning act; one egg is laid at a time on a hard surface; the males are very black in the breeding season; both have a complicated flower-like urogenital papilla; and, the young are very similar in appearance.

What has been proposed here is that the glassy darter, a social-communal type of spawner, has evolved from the complicated territorial society of the johnny darter. Winn (1958b) proposed that the darters evolved from a loose type of schooling or aggregational spawning into a graded series of territorial societies. This new communal type of reproduction, however, represents many narrowly adaptive features; more so than the johnny darter type, so that it could be of more recent origin.

Summary

Etheostoma vitreum, the glassy darter, spawns during three to four weeks in late March to April in water with temperatures that range from 10° to 18°C. The eggs are deposited on a solid surface that is in the

path of a strong current. The egg sites are near fine shifting sand areas where this fish lives most of the year. These fish spawn in large communal numbers where aggressiveness is reduced to a minimum. Other details of reproduction are described and discussed.

Biological data seem to relate this fish to the the boleosomid darters. It is proposed that the glassy darter with a unique communal spawning habit, has evolved from boleosomid-like darters with specialized territorial reproductive habits.

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Literature Cited

WINN, H. E. 1958a. Observations on the reproductive habits of darters (Pisces-Percidae). *Amer. Midl. Nat. 59(1):190–212.*

———. 1958b. Comparative reproductive behavior and ecology of fourteen species of darters (Pisces-Percidae). *Ecol. Monogr. 28(1): 155–191.*

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Comparative Morphometry of the Mountain Whitefish, *Prosopium williamsoni*[1]

RAMONA DENTON HOLT

Introduction

THE coregonines are known to be a plastic group, even within genera. Considerable variation in the meristic characters of *Prosopium williamsoni* was noted by McHugh (1936). Weisel and Dillon (1954) compared *P. williamsoni* with *P. coulteri* and reported variations in both species. Dymond (1943) found similar degrees of variation in *P. cylindraceum, P. oregonium* and *P. coulteri.* Kennedy's (1953) measurements and counts on *P. cylindraceum* agree with Dymond's (1943) results.

Thirteen collections of adult *P. williamsoni* were examined to compare body proportions and meristic characters and to study local variations of the species. Twenty-three counts and 34 measurements were made on 357 specimens. These fish were collected from three major drainages in five states (Fig. 1).

Five collections were obtained from the Missouri River drainage as follows: (1) Tongue River, above Dayton, Wyoming; (2) South Fork of Shoshone River, in and above Buffalo Bill Reservoir, Wyoming; (3) Yellowstone River, 17 miles below Livingston, Montana; (4) Hebgen Lake, an impoundment on the Madison River, at West Yellowstone, Montana; and (5) Red Rock Creek, above Upper Red Rock Lake in the headwaters of the Jefferson River, Montana. The Tongue River and the South Fork of the Shoshone River are tributaries of the lower Yellowstone River. These two collections and the one from Yellowstone River are more or less isolated from one another by the high temperature of the lower Yellowstone River. Whitefish are rarely taken below Billings, however a few have been reported downstream as far as Miles City, Montana. The whitefish from Hebgen Lake and Red Rock Creek are not isolated from each other by natural barriers, although artificial barriers to upstream movement exist in the headwaters of the Jefferson River and Madison River at the present time.

Six samples were collected from the Columbia River drainage as follows: (6) Bitterroot River, Lolo, Montana; (7) Whitefish River, above Kalispell, Montana; (8) Thompson Lakes, in the headwaters of Thompson River, Montana; (9) Lake Pend Oreille, on the Clark Fork River, Idaho; (10) Phelps Lake, in Grand Teton National Park, Wyoming; and (11) McKenzie River, below Leaburg Dam, Eugene, Oregon. The Bitterroot

[1] Contribution from Montana State College Agricultural Experiment Station, Project No. MS8444-2, Paper No. 384, Journal Series.

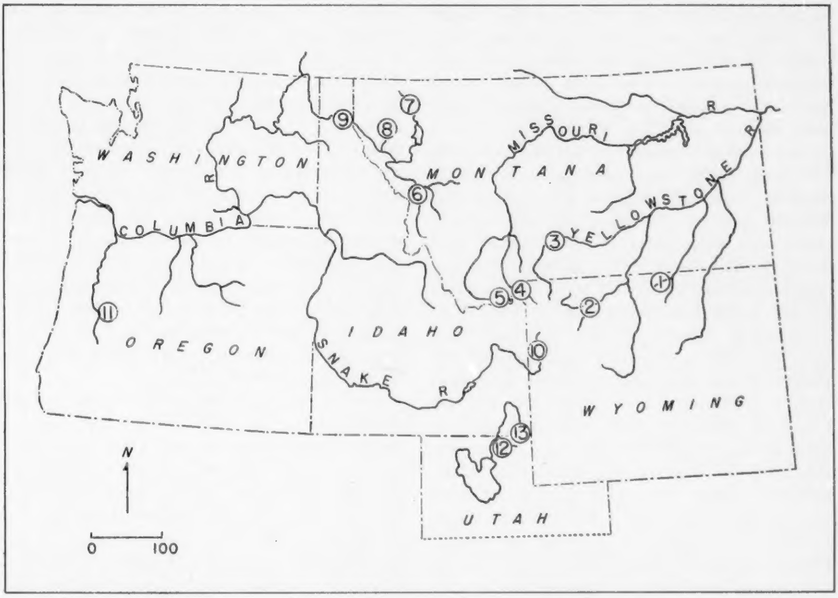

Fig. 1.—Map of northwestern United States showing location of collections. (1) Tongue River, (2) South Fork of Shoshone River, (3) Yellowstone River, (4) Hebgen Lake, (5) Red Rock Creek, (6) Bitterroot River, (7) Whitefish River, (8) Thompson Lakes, (9) Lake Pend Oreille, (10) Phelps Lake, (11) McKenzie River, (12) Logan River and (13) Bear Lake.

River, Whitefish River and Thompson River are in the drainage of the Clark Fork River in Montana. The Clark Fork River flows through Lake Pend Oreille in Idaho and enters the Columbia River in Canada. Phelps Lake is the extreme headwaters of the Snake River and the McKenzie River is tributary to the Willamette River and the lower Columbia River. No natural barriers separated the whitefish taken from the Columbia River drainage with the exception of those from Phelps Lake. Numerous dams now prevent upstream movement of whitefish in this drainage.

The two collections from the Bear River drainage of the interior Bonneville Basin are: (12) Logan River, above Logan, Utah, and (13) Bear Lake, in the upper portion of Bear River, Idaho and Utah. Collection 13 was omitted from this report because of confusion with other species in the lake. These collections are from tributaries of Bear River which enters Great Salt Lake. No natural barriers exist in this drainage.

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Methods

All whitefish were preserved in 10 percent formalin. The coelomic cavity of the larger specimens was either injected with formalin or cut open to insure penetration of the preservative. Each collection was soaked in water for a day before examination.

Measurements and counts—Measurements and counts follow the system outlined by Hubbs and Lagler (1947). All measurements were taken to the nearest 0.1 mm. with calipers, except standard and total lengths which were determined to the nearest mm. on a measuring board. All weights were to the nearest 0.01 pound. Scale counts were taken

as follows: lateral-line scales, dorsal origin to lateral line, anal origin to lateral line, predorsal rows, predorsal scales, body circumference rows above and below lateral line, and caudal peduncle circumference rows above and below lateral line. Fin-ray counts were determined for all fins and both left and right branchiostegal rays were counted. Gillraker counts were made on the first gill arch of the right side. The pyloric caeca were separated from the stomach and counted individually. The number of vertebrae was determined after making a sagittal section parallel to the vertebral column.

Statistical treatment—All meristic data and 25 body proportions were tested by analysis of variance in six different combinations of drainages and collections, making a total of 336 tests. These test combinations were: (a) among all 12 collections; (b) among drainages (Missouri River, Columbia River and Bear River drainages); (c) among non-mixing populations of Columbia River drainage (Bitterroot River, Whitefish River, Thompson Lakes and Lake Pend Oreille collectively, and Phelps Lake and McKenzie River separately); (d) within mixing populations of Columbia River drainage (Bitterroot River, Whitefish River, Thompson Lakes and Lake Pend Oreille); (e) among non-mixing populations of Missouri River drainage (Tongue River, South Fork of Shoshone River, and Yellowstone River separately, and Hebgen Lake and Red Rock Creek collectively); and (f) within mixing populations of Missouri River drainage (Hebgen Lake and Red Rock Creek). The significance of the results was determined at the 5 percent and 1 percent levels.

Comparison of Body Proportions and Counts

Analysis of variance of the means of most ratios and counts was significant at the 1 percent level. It seemed imperative to compare the tests with the ranges and averages for all collections (Table I). Only those which were significant at the 1 percent level and had differences in ranges or averages are discussed below.

Among all 12 collections (a).—The variance of the means for all body proportions and meristic counts was significant at the 1 percent level. However, the ranges overlapped for many proportions and counts (Table I). Collection 6 has a lower head in length range than collections 10 and 12. The range of depressed anal in length is lower in collection 1 than in 10. The caudal base to longest ray in length is higher in collection 5 than in 9. Collection 1 has a lower range for pelvic in length than 10 and the range for orbit in length of collection 4 is greater than in 6. The range of adipose height in adipose base of collection 5 is lower than in 9. Collections 1, 2, 8, 9, and 12 have fewer scales below the lateral line than 3 and 5. Collections 3 and 4 have a greater body circumference rows total than collections 7 and 8. Collections 1 and 3 have 17–20 gillrakers whereas collection 6 has 21–25. Collections 1, 2, 9, and 12 have 58–61 vertebrae and collections 5, 8, and 11 have 53–58. Collection 8 has a lower range of pyloric caeca than collection 12.

Among drainages (b).—The averages of depressed dorsal in length, depressed anal in length, pelvic finlet in pelvic fin, and vertebrae are lower for the collections from the Missouri River and Columbia River drainages than from the Bear River drainage. Columbia River and Bear River drainages average larger body width in length and adipose height in adipose base ratios than the Missouri River drainage. The ratios of isthmus width in isthmus length and gillraker count of the Columbia River drainage are higher than for the Missouri River and Bear River drainages. The Missouri River drainage averages a larger ratio of orbit in length than the other drainages.

Among non-mixing populations of Columbia River drainage (c).—Collection 11 has larger orbit in length and caudal base to longest ray in length than collection 10 and the four mixing populations (6, 7, 8, and 9). Collection 10 averages greater depressed anal in length and pelvic in length ratios than the other collections. The mixing populations average fewer predorsal scales and pyloric caeca and more gillrakers than collections 10 and 11. The average isthmus width in isthmus length for colleciton 10 is much higher than for other collections. Collection 11 (McKenzie River) compares quite favorably with *P. oregonium* described by Jordan and Snyder (1909), but also falls within the range of ratios and counts of all other *P. williamsoni* of the present study.

Within mixing populations of Columbia River drainage (d).—These collections compare closely in most ratios and counts. Collections 6 and 7 average a greater head width in head, and a lower adipose height in adipose base than collections 8 and 9. The average dorsal rays was smallest for collection 8.

TABLE I

RANGES AND AVERAGES OF BODY PROPORTIONS AND MERISTIC COUNTS OF *Prosopium williamsoni*

Drainage	Missouri River					Columbia River						Bear River
Collection	1	2	3	4	5	6	7	8	9	10	11	12
Number of specimens	30	30	30	30	30	24	50	30	27	30	30	16
Head in length	4.2–4.8	4.3–5.0	4.0–4.7	4.4–5.0	4.3–5.0	4.1–4.6	4.0–4.7	4.6–5.0	4 5–5.1	4.6–5.4	4.3–5.0	4.7–5.3
	4.5	4.6	4.4	4.8	4.7	4.4	4.4	4.8	4.7	5.1	4.7	4.9
Predorsal in length	2.0–2.4	2.2–2.5	2.0–2.4	2.1–2.4	2.2–2.4	2.2–2.4	2.2–2.5	2.1–2.4	2.1–2.4	2.2–2.5	2.1–2.3	2.1–2.6
	2.2	2.3	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.3	2.2
Body depth in length	4.1–5.3	4.2–5.1	3.9–5.1	3.8–5.1	4.1–4.9	4.5–5.0	4.2–5.3	4.3–5.3	4.5–5.5	4.3–5.9	4.2–4 9	4.1–5.1
	4.7	4.6	4.5	4.3	4.5	4.7	4.8	4.8	4.9	4.9	4.6	4.6
Body width in length	6.3–7.7	6.1–8.0	5.8–7.4	5.3–8.4	5.6–7.0	6.0–7.2	6.5–8.7	6.9–8.4	6.9–9.3	6.6–8.3	6.2–8.1	6.2–8.2
	6.9	7.0	6.6	6.3	6.3	6.6	7.3	7.7	7.7	7.5	7.0	7.3
Dorsal origin to occiput in length	3.1–3.7	3.2–3.9	3.0–4.1	3.1–3.8	3.1–3.8	3.2–3.6	3.1–3.9	3.1–3.9	3.0–4.3	3.2–3.9	3.1–3.7	3.2–3.7
	3.4	3.5	3.4	3.4	3.4	3.4	3.4	3.5	3.5	3.6	3.4	3.4
Anal origin to CB in length	3.5–4.1	3.5–4.1	3.8–4.3	3.7–4.3	3.6–4.2	3.8–4.2	3.8–4.6	3.8–4.4	3.7–4.3	3.8–4.4	3.6–4.3	3.7–4.0
	3.8	3.9	4.1	4.0	3.9	4.0	4.2	4.1	4.0	4.1	4.0	3.8
CB to adipose origin in length	4.7–5.6	4.5–5.4	4.7–5.6	4.7–5.6	4.6–5.6	4.4–5.1	4.5–6.1	4.3–5.0	4.3–5.2	4.5–5.6	4.5–5.3	4.5–5.1
	5.1	4.9	5.1	5.1	4.9	4.8	5.0	4.6	4.8	5.1	4.9	4.8
CB to longest ray in length	4.4–5.3	4.5–5.6	4.6–5.5	4.7–6.1	5.1–6.2	4.7–5.6	4.4–5.7	4.2–5.2	4.4–4.9	4.5–5.7	4.6–6.6	4.7–6.2
	4.9	5.3	5.1	5.3	5.7	5.1	4.9	4.6	4.6	5.0	5.4	5.5
Depressed dorsal in length	4.4–5.6	4.5–5.4	4.6–5.6	4.5–5.6	4.7–5.7	4.6–5.2	4.5–5.7	4.6–5.6	4.5–5.2	4.8–5.9	4.6–6.2	4.7–5.6
	4.9	4.9	5.1	4.8	5.1	4.9	5.1	5.2	5.0	5.3	5.3	5.2
Depressed anal in length	5.8–6.5	5.6–7.2	5.7–7.0	6.2–7.5	6.4–7.8	6.0–7.3	5.9–7.6	6.4–7.9	5.9–7.3	6.8–8.2	6.1–7.3	6.3–7.1
	6.2	6.5	6.3	6.9	7.1	6.5	6.5	7.1	6.7	7.6	6.6	6.7
Pectoral in length	5.0–5.8	5.0–6.2	5.2–6.0	5.6–6.9	5.6–6.9	5.2–6.1	4.8–6.1	4.9–5.8	5.1–6.1	5.5–6.8	5.5–6.9	5.8–6.5
	5.5	5.7	5.6	6.1	6.3	5.8	5.4	5.4	5.6	6.2	6.1	6.1
Pelvic in length	5.6–6.5	5.8–7.3	5.6–6.7	6.4–7.4	6.3–7.7	5.8–7.2	5.6–7.4	6.1–7.2	5.9–7.1	6.7–8.3	6.2–8.0	6.3–7.6
	6.1	6.5	6.1	6.9	7.0	6.6	6.4	6.6	6.6	7.4	6.8	6.9
Standard length	150–246	113–352	182–380	173–413	151–356	228–302	203–300	220–268	162–271	207–265	164–405	157–398
	199.0	250.1	261.6	290.2	233.9	256.7	251.3	235.4	209.8	232.7	242.0	227.9
CP depth in CP length	1.8–2.2	1.3–2.3	1.7–2.2	1.5–2.1	1.8–2.3	2.0–2.4	1.8–2.5	2.1–2.9	2.1–2.7	1.7–2.5	1.6–2.2	1.9–2.3
	2.0	2.0	2.0	1.9	2.0	2.2	2.1	2.4	2.4	2.1	1.9	2.0
Head width in head	1.9–2.2	1.8–2.1	1.8–2.7	1.7–2.0	1.6–2.1	2.2–2.6	2.4–2.9	1.9–2.2	2.0–2.3	2.0–2.9	1.6–2.0	1.8–1.9
	2.0	2.0	2.1	1.8	1.9	2.4	2.6	2.0	2.1	2.3	1.9	1.9

TABLE I—*Continued*

Drainage	Missouri River					Columbia River						Bear River
Collection	1	2	3	4	5	6	7	8	9	10	11	12
Interorbitalin head	3.2–4.4	3.2–4.5	3.2–4.3	3.1–3.8	2.4–4.2	3.5–4.1	3.2–4.3	3.1–3.7	3.2–4.1	3.3–3.8	3.2–3.8	3.1–3.8
	4.0	3.7	3.9	3.4	3.7	3.8	3.8	3.4	3.7	3.6	3.5	3.5
Snout in head	3.1–3.8	3.1–4.1	2.9–3.6	3.1–3.9	3.1–4.0	3.1–3.7	2.8–3.9	3.2–3.9	3.3–3.9	3.3–4.1	3.1–4.0	3.1–4.1
	3.5	3.5	3.2	3.6	3.6	3.3	3.3	3.6	3.5	3.7	3.6	3.7
Orbit in head	4.1–6.0	4.1–6.2	4.0–6.2	4.9–7.3	3.8–6.7	3.9–4.8	3.9–5.2	4.0–5.2	3.6–5.3	3.6–5.3	3.7–6.5	4.3–6.9
	4.9	5.6	5.1	6.1	4.8	4.3	4.4	4.6	4.3	4.5	4.8	5.4
Upper jaw in head	3.0–4.0	3.2–4.1	2.9–4.1	3.4–4.1	2.8–4.2	3.2–3.9	3.1–3.9	3.2–3.9	3.6–4.1	3.5–4.4	3.2–4.3	3.2–4.1
	3.5	3.6	3.3	3.6	3.6	3.5	3.5	3.7	3.8	3.9	3.7	3.7
CP length in head	1.3–1.6	1.2–1.6	1.3–1.7	1.3–1.7	1.2–1.6	1.4–1.7	1.3–1.9	1.2–1.5	1.2–1.6	1.1–1.7	1.3–1.7	1.2–1.5
	1.4	1.4	1.5	1.4	1.4	1.5	1.6	1.4	1.4	1.4	1.5	1.4
Suborbital in upper jaw	2.8–4.1	2.6–3.9	2.5–3.7	2.5–3.5	1.9–3.5	2.2–3.0	2.4–3.9	2.7–4.3	2.7–3.9	2.2–3.7	2.2–3.8	2.9–4.2
	3.3	3.2	3.1	3.0	2.8	2.7	3.0	3.1	3.2	2.9	2.9	3.3
Pelvic finlet in pelvic fin	2.8–3.8	2.5–4.0	2.5–3.7	2.3–3.7	2.6–4.0	2.2–3.6	2.3–4.2	2.3–3.3	2.3–4.4	2.6–3.6	2.0–4.8	2.9–4.9
	3.1	3.1	3.0	3.1	3.0	2.8	2.9	2.7	2.9	3.0	3.3	3.4
Dorsal base in depressed dorsal	1.4–1.7	1.4–1.7	1.4–1.6	1.3–1.7	1.3–1.6	1.4–1.7	1.4–1.8	1.3–1.7	1.5–1.6	1.4–1.6	1.3–1.5	1.4–1.6
	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.5	1.5	1.5	1.5
Anal base in depressed anal	1.3–1.7	1.3–1.6	1.3–1.9	1.2–1.6	1.3–1.6	1.5–1.7	1.3–1.9	1.4–1.8	1.4–1.7	1.2–1.7	1.3–1.7	1.3–1.5
	1.5	1.5	1.6	1.4	1.4	1.6	1.6	1.6	1.5	1.4	1.4	1.4
Adipose height in adipose base	1.8–3.8	1.9–3.1	1.6–3.3	2.3–3.5	1.8–2.8	1.6–2.8	1.9–3.5	2.4–6.5	2.9–5.6	1.7–5.4	1.7–4.3	2.2–4.1
	2.4	2.3	2.4	2.8	2.3	2.1	2.5	3.9	3.9	3.1	2.9	3.1
Isthmus width in isthmus length	2.4–4.1	2.0–4.4	2.0–3.6	1.1–3.2	...	...	...	2.3–6.1	2.4–5.1	2.8–5.9	2.3–2.4	1.9–3.3
	3.1	3.0	2.7	2.2	...	...	...	3.7	3.3	4.0	2.4	2.4
Branchiostegals (right)	7–9	8–9	7–9	7–9	7–9	...	...	7–8	7–9	7–9	7–9	8–9
	8.0	8.4	8.2	8.0	8.1	...	...	7.1	8.0	8.1	8.2	8.3
Branchiostegals (left)	7–9	7–9	8–9	7–9	7–10	...	...	7–9	7–9	5–9	7–10	8–9
	7.8	8.4	8.6	8.3	8.2	...	...	7.7	7.9	7.8	8.6	8.6
Dorsal rays	11–13	12–14	12–14	11–13	11–14	12–14	12–14	11–12	12–14	11–14	11–13	12–13
	12.3	12.3	12.6	12.4	13.1	12.7	12.6	11.4	12.5	12.4	12.3	12.5
Anal rays	10–12	10–12	10–12	10–12	10–12	10–12	10–12	10–12	10–12	10–12	10–13	11–12
	11.1	11.1	11.3	10.7	11.3	11.3	11.2	10.4	10.9	11.3	11.7	11.5
Pectoral rays (right)	15–17	15–17	15–17	15–17	15–18	10–17	15–19	15–18	15–18	15–18	14–16	15–16
	12.7	15.6	15.7	15.9	16.4	15.7	15.6	16.7	16.1	16.0	15.4	15.9
Pectoral rays (left)	15–16	15–16	14–17	15–18	15–18	14–16	14–18	15–18	15–18	15–18	14–17	14–16
	15.8	15.5	15.4	16.1	16.5	15.8	15.6	16.6	16.0	16.6	15.2	15.4

Pectoral rays (left)	15–16	15–16	14–17	15–18	15–18	14–16	14–18	15–18	15–18	15–18	14–17	14–16
	15.8	15.5	15.4	16.1	16.5	15.8	15.6	16.6	16.0	16.6	15.2	15.4
Pelvic rays (right)	10–11	10–12	11–12	10–11	10–12	10–13	10–12	10–11	10–11	10–12	8–11	10–11
	10.9	10.7	11.1	10.8	11.1	11.1	10.9	10.9	10.9	10.8	10.5	10.5
Pelvic rays (left)	10–11	10–12	10–12	10–11	11–12	10–12	10–12	10–11	10–11	10–13	10–11	9–11
	10.9	10.8	10.9	10.5	11.3	11.0	10.9	10.9	10.8	10.6	10.1	10.4
Caudal rays	19	19	19	19–20	18–21	19–21	19–21	19	19	18–20	18–20	19
	19	19	19	19.1	19.1	20.0	19.9	19	19	18.9	10.9	19
Lateral line	80–89	79–89	75–92	80–90	78–87	74–85	74–85	76–83	74–88	73–87	75–91	81–89
	83.7	83.6	82.8	84.8	82.9	79.4	80.9	79.2	79.7	80.2	82.4	84.3
Scales above lateral line	9–10	9–10	9–10	10–11	9–11	9–11	9–10	9–9	8–10	8–11	9–10	9–10
	9.0	9.1	9.8	10.2	9.9	10.0	9.5	9.0	8.9	10.2	9.7	9.1
Scales below lateral line	7–8	7–8	8–10	7–10	8–10	8–9	7–9	7–7	6–8	7–9	7–9	7–82
	7.2	7.2	9.1	8.7	8.3	8.4	8.0	7.0	7.0	8.2	8.2	7.3
Predorsal rows	29–32	29–33	28–34	29–35	29–35	26–31	27–31	28–30	27–30	28–32	29–35	28–3
	30.2	29.8	30.7	30.9	32.1	28.8	28.8	28.8	29.0	29.8	31.8	30.2
Predorsal scales	31–35	31–36	31–36	29–37	30–37	29–35	29–35	29–33	28–36	30–36	31–37	31–39
	32.6	32.8	33.4	34.0	33.8	31.3	31.6	30.9	31.6	32.4	34.1	34.6
Body circum. rows (above LL)	19–21	19–22	20–21	20–23	18–22	18–21	17–20	18–20	18–20	20–22	19–23	19–21
	19.8	19.8	20.3	21.0	20.1	19.0	18.7	18.9	19.2	20.7	20.0	19.6
Body circum. rows (below LL)	24–27	24–27	25–28	25–29	25–28	23–26	22–25	23–25	22–26	24–27	22–27	23–26
	25.7	24.9	26.5	26.9	26.2	24.5	23.4	23.7	23.8	25.1	24.7	24.5
Body circum. rows (total)	46–50	45–50	47–51	47–53	45–50	43–48	41–47	43–47	43–48	47–50	43–50	44–48
	47.5	46.8	48.8	50.0	48.3	45.7	44.1	44.6	45.1	47.8	46.8	46.2
CP circum. rows (above LL)	10	9–10	10–11	9–11	9–10	9–10	8–10	9–9	9–10	9–10	8–10	9–10
	10	9.8	10.1	10.1	9.9	9.5	9.3	9.0	9.2	9.7	9.3	9.4
CP circum. rows (below LL)	9–10	9–10	9–10	9–11	9–10	9–10	8–10	9–9	9–10	9–10	9–10	9–10
	9.9	9.8	9.9	10.0	9.8	9.2	9.2	9.0	9.3	9.5	9.3	9.1
CP circum. rows (total)	21–22	20–22	21–23	21–24	20–22	20–22	19–22	20–20	20–22	20–22	19–22	20–22
	21.9	21.6	22.0	22.1	21.7	20.7	20.4	20.0	20.5	21.2	20.6	20.5
Gillrakers	17–20	19–22	18–20	18–23	18–23	21–25	19–25	19–24	18–23	18–23	18–22	18–21
	18.0	20.4	19.1	19.9	20.7	22.6	22.1	21.4	20.4	19.4	19.8	20.1
Vertebrae	58–61	58–61	53–59	55–60	53–58	56–59	55–59	53–58	58–61	54–59	53–58	58–61
	59.5	59.7	56.6	56.9	55.5	57.2	57.1	55.5	59.4	57.9	55.7	59.5
Pyloric caeca	75–116	76–116	68–130	79–143	65–146	73–125	82–117	61–95	67–105	50–132	90–128	99–126
	91.5	89.9	102.3	109.7	113.1	97.2	98.2	77.6	86.9	100.7	104.6	110.4

Among non-mixing populations of Missouri River drainage (e).—The two mixing populations have the highest depressed anal in length, pectoral in length, pelvic in length and caudal base to longest ray in length averages. They have more pectoral rays and pyloric caeca and lower averages of body width in length, head width in head, interorbital in head and suborbital in upper jaw ratios than collections 1, 2, and 3.

Within mixing populations of Missouri River drainage (f).—Collection 4 averages a smaller caudal base to longest ray in length ratio and a larger orbit in head ratio than collection 5. They compare favorably in other ratios and counts.

The ranges overlap for most of the above proportions and counts, but the averages are distinct. The variations between collections are numerous. Dymond (1943) noted considerable variation in body form and fin lengths of *P. cylindraceum* from one locality to another even in the same region. It is probable that *Prosopium* is even more subject to environmental modification than *Coregonus* or *Leucichthys* (Dymond, 1943). Only three isolated collections vary extremely from other collections in body proportion averages: collection 4 (Hebgen Lake), orbit in head and isthmus width in isthmus length; collection 10 (Phelps Lake), head in length, depressed anal in length, pelvic in length and isthmus width in isthmus length. The meristic-count averages of each collection vary little from the grand means.

The body proportion averages differ somewhat between drainages. The body width in length ratios are high in the collections of the Columbia River and Bear River drainages, but low in those of the Missouri River drainage. The depressed anal in length, orbit in head, adipose height in adipose base and isthmus width in isthmus length ratios also vary among drainages. However, this variance is due to extreme values of one or two collections and not all collections of the drainage.

All collections were checked for sex dimorphism. No readily apparent differences in sexes were observed except a slight difference in length of fins. This variation did not seem substantial enough to warrant separating the sexes in collections.

Comparison of Six Coregonine Fishes

Five body proportions and counts of six coregonine fishes (*P. williamsoni, P. oregonium, P. spilonotus, P. coulteri, P. cylindraceum,* and *Coregonus clupeaformis*) are compared (Table II). Dymond's (1943) body proportions and dorsal ray counts of *P. oregonium* differ considerably from the original description of this species (Jordan and Snyder, 1909). This probably is a result of a different method of measuring and counting. The type specimen has a longer snout and upper jaw, more compressed and slender body and more slender caudal peduncle. A large adipose is one character which distinguishes the type of *P. oregonium*. The whitefish from the McKenzie River (collection 11) agree with the type in measurements and counts, but do not have an unusually large adipose. *P. spilonotus* differs from *P. oregonium* in numbers of dorsal rays, anal rays and gillrakers. *P. oregonium* does not vary greatly in any character from the measurements of *P. williamsoni*.

P. coulteri (Weisel and Dillon, 1954; Eschmeyer and Bailey, 1955) differs from the other species in four characters (lateral line, dorsal rays, orbit in head and body depth in length). Each meristic average is lower in *P. coulteri* than *P. williamsoni* and there is no overlap in the lateral line and gillraker counts. *P. coulteri,* however, is a dwarf species.

The two studies (Kennedy, 1953; Dymond, 1943) of *P. cylindraceum* do not differ appreciably. *P. cylindraceum* varies from the other species in most body proportions and the lateral line count.

The two distinguishing meristic characters of *C. clupeaformis* are number of gillrakers and branchiostegal rays (McHugh, 1939; Kennedy, 1953). Body proportions vary among populations in different waters. Kennedy's method of counting dorsal and anal rays is the same as Dymond's (1943). All of the unbranched rays at the front of the fins, no matter how short, were counted. These were added to the number of branched rays and the total number indicated as the number of fin rays. The last ray of the dorsal and anal fins was counted as one, even though divided to the base and appearing as two separate rays. This method is very different from Hubbs and Lagler's recommended procedure.

P. williamsoni, P. coulteri, P. cylindraceum, and *C. clupeaformis* are readily distinguishable species but *P. oregonium* falls within the ranges of *P. williamsoni*.

Table II

Ranges and Averages of Body Proportions and Counts of Six Coregonine Fishes

	Species											
	P. williamsoni			*P. oregonium*		*P. spilonotus*	*P. coulteri*		*P. cylindraceum*		*C. clupeaformis*	
	Study											
	Present study	McHugh (1939)	Weisel & Dillon (1954)	Dymond (1943)[1]	Jordan & Snyder (1909)	Snyder (1917)	Weisel & Dillon (1954)	Eschmeyer & Bailey (1955)	Kennedy (1953)[1]	Dymond (1943)[1]	McHugh (1939)	Kennedy (1953)
Number of specimens	357	19	6	6	5	22	23	10	8	4	40	78
Head in length	4.0	...	4.4	4.5	4.0	3.6	3.9	3.8	5.0	5.1	...	...
	–5.4		–4.7	–4.8	–4.6	–4.6	–4.4	–4.3	–5.6	–5.6		
	4.7	...	4.5	4.7	4.3	4.1	4.1	4.0	5.3	5.4	...	...
Body depth in length	3.8	...	4.3	3.4	...	3.6	4.8	4.6	4.9	4.5	...	...
	–5.9		–5.0	–4.8		–4.8	–5.9	–4.9	–5.9	–5.5		
	4.6	...	4.6	3.9	5.0	4.3	5.3	4.8	5.4	4.8	...	...
Snout in head	2.8	...	...	2.9	2.6	2.8	...	4.1	3.8	...	...	3.1
	–4.1			–3.5	–3.5	–4.0		–4.3	–4.4			–3.9
	3.5	...	...	3.2	3.0	3.3	...	4.2	4.2	3.6	...	3.4
Orbit in head	3.6	...	4.0	4.4	...	3.3	3.0	3.5	4.4	...	...	4.0
	–7.3		–4.3	–5.3		–5.3	–3.7	–3.5	–5.0			–6.2
	5.4	...	4.1	4.8	5.5	4.3	3.4	3.5	4.7	5.0	...	5.0
Upper jaw in head	2.8	...	3.6	3.2	2.9	2.8	3.2	3.1	4.3	...	...	2.7
	–4.4		–4.2	–3.9	–3.6	–4.2	–4.1	–3.4	–4.8			–3.7
	3.6	...	3.8	3.6	3.2	3.5	3.4	3.2	4.5	4.3	...	3.3
Branchiostegals	7–9	7–9	...	8–9	...	...	...	...	7–8	8–8	8–10	8–10
	8.0	8.0	...	8.3	8.0	8.0	...	...	7.1	8.0	9.0	9.2
Dorsal rays	11–14	11–14	12–13	14–15	12–13	10–12	9–11	10–12	13–15	13–14	10–12	12–16
	12.5	12.0	12.5	14.0	12.6	10.8	9.7	11.0	14.4	13.5	11.0	13.7
Anal rays	10–13	10–12	12–13	12–14	11–12	9–11	9–11	12–14	11–13	12–13	9–13	12–16
	11.5	11.0	12.5	12.8	11.8	10.1	9.9	13.0	12.0	12.5	11.0	13.8
Lateral line	73–92	75–89	74–77	77–88	81–86	74–81	54–63	54–62	86–102	90–100	75–85	72–85
	82.5	82.0	75.0	82.5	84.6	77.7	59.7	57.1	91.2	95.0	77.0	77.8
Gill rakers	17–25	17–25	19–23	22–24	...	18–22	13–16	16–20	17–21	18–19	26–31	23–31
	20.2	22.0	...	22.4	19.0	19.0	...	18.3	19.4	18.8	29.0	27.0

[1] Actual body measurements were recalculated from given data and used to obtain resulting proportions.

Discussion

No collection is distinguishable from all other collections of the present study by ranges of body proportions or meristic counts. Only one character (head width in head) separates collection 11 from the other collections of the Columbia River drainage. *P. oregonium* cannot be separated from *P. williamsoni* by body ratios or counts.

Summary

1. Whitefish were obtained from three major drainages as follows: (1) Tongue River, (2) South Fork of Shoshone River, (3) Yellowstone River, (4) Hebgen Lake, and (5) Red Rock Creek; Columbia River drainage, (6) Bitterroot River, (7) Whitefish River, (8) Thompson Lakes, (9) Lake Pend Oreille, (10) Phelps Lake, and (11) McKenzie River; Bear River drainage, and (12) Logan River.

2. Measurements and counts were taken on all 357 fish. The means of body ratios and meristic characters were tested by analysis of variance in seven different combinations.

3. The majority of the tests were significant at the 1 percent level. The ranges of variation for most body proportions and counts overlapped, but some means differed greatly among collections and drainages.

4. Collections from McKenzie River were not distinguishable among all collections.

5. Body proportions and meristic characters from 12 studies of 6 coregonine fishes (*P. williamsoni*, *P. oregonium*, *P. spilonotus*, *P. coulteri*, *P. cylindraceum*, and *C. clupeaformis*) were compared. All species except *P. oregonium* were distinguishable from one another. The body proportion and count ranges of *P. oregonium* fell within the ranges of *P. williamsoni*.

Literature Cited

Dymond, J. R. 1943. The coregonine fishes of northwestern Canada. *Trans. Roy. Can. Inst. 24(2):171–231.*

Eschmeyer, Paul H., and Bailey, Reeve M. 1955. The pygmy whitefish, *Coregonus coulteri*, in Lake Superior. *Trans. Amer. Fish. Soc. 84:161–199.*

Hubbs, Carl L., and Lagler, Karl F. 1947. Fishes of the Great Lakes region. *Cranbrook Inst. Sci., Bull. 26:1–186.*

Jordan, David Starr, and Snyder, John Otterbien. 1909. Description of a new whitefish (*Coregonus oregonius*) from McKenzie River, Oregon. *Proc. U. S. Nat. Mus. 36:425–430.*

Kennedy, W. A. 1953. The morphometry of the coregonine fishes of Great Bear Lake, N. W. T. *Jour. Fish. Res. Bd. Can. 10(2):51–61.*

McHugh, J. L. 1939. The whitefishes *Coregonus clupeaformis* (Mitchill) and *Prosopium williamsoni* (Girard) of the lakes of the Okanagan Valley, B. C. *Bull. Fish. Res. Bd. Can. 56:39–50.*

Snyder, John Otterbean. 1917. Three new whitefishes from Bear Lake, Idaho and Utah. *Bull. Bur. Fish. 36:3–6.*

Weisel, George F., and Dillon John B. 1954. Observations on the pygmy whitefish, *Prosopium coulteri* from Bull Lake, Montana. Copeia, 1954 *(2):124–127.*

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The Stomiatoid Fish Genera *Eustomias* and *Melanostomias* in the Pacific, with Descriptions of Two New Species

Robert H. Gibbs, Jr.

The genus *Eustomias*, although the most-speciose of the stomiatoids, has not previously been known outside the Atlantic Ocean and adjacent seas. The most recent extensive study of *Eustomias* (Regan and Trewavas, 1930) treated 52 species, and a few new ones have been described since that time, all from the Atlantic. While this number of species is undoubtedly too high, as will be shown in my revision in the forthcoming volume of *Fishes of the Western North Atlantic*, the fact remains that *Eustomias* still includes far more species than any other stomiatoid genus. It is, therefore, almost a relief to report for the first time, the presence of *Eustomias* species in the Pacific. Two new species are described here, and a third, already known from the Atlantic, is recorded.

The genus *Melanostomias* was previously known in the Pacific only from the type of *M. pauciradius* Matsubara, taken off Japan. The genus is shown here to be represented in the central and eastern Pacific by two species, one of which was formerly known only from the Azores and the Western Atlantic, the other from both the Atlantic and eastern Indian oceans.

In designating groups of photophores, the hyphen is dropped from all terms, and the VA groups have been designated as VAL in the lateral row and VAV in the ventral row, doing away with the confusion wherever just V-A used to appear without designation. The groups are: in the ventral series, IP, isthmus to pectoral insertion; PV, pectoral insertion to pelvic (ventral) insertion; VAV, pelvic insertion to end of ventral row over anal base (usually ends well behind origin); in the lateral series, OV, behind operculum to pelvic insertion; VAL, pelvic insertion to over anal base; AC, begins behind and between the ends of VAV and VAL, and continues to near end of caudal peduncle. All fin rays are counted, not just principal rays.

Eustomias bulbornatus sp. nov.

Holotype.—USNM 150566. Collected by the vessel Albatross at 30°22′N, 129°08′30″E, Gwaja Shima, Japan, August 13, 1906. Standard length 95.8 mm. This is the only known specimen.

Comparative Diagnosis.—A species of *Eustomias* with three pectoral rays and a barbel which has a single terminal bulb bearing an ornate assemblage of terminal appendages. The structure of the barbel is unique. Other species have terminal appendages which consist of bunches of short filaments or long, much-branched, but comparatively simple extensions. The complicated array of *E. bulbornatus* most closely suggests the type of structure seen in some species, such as *E. bigelowi* or *E. fissibarbis,* in which three branches arise from the main stem, which then continues on to end in a separate distal bulb.

E. bulbornatus, therefore, does not appear closely related to any known species of *Eustomias.* It would fall into Regan and Trewavas' multivariate subgenus *Nominostomias* by default, but I do not feel that any previously proposed subgenera are worthy of consideration in the light of present knowledge.

Description.—Body long, slender, the greatest depth 14.2 in standard length. Head about 8 in standard length, the snout protractile. Bony orbit about 3.3 in head, slightly longer than snout. Postocular organ much smaller than eye, about one-sixth of fleshy orbit diameter. Premaxillary teeth 10 on left side, the second and third fangs contiguous (replacement occurring?), the third fang longest; first fang and fifth small side tooth fixed, the rest depressible. Maxilla with a series of fine serrations. Mandibular teeth 14 on left side, the first two and three other side teeth fixed, the remainder depressible. No vomerine or palatine teeth. Three pairs of basibranchial teeth. No gillrakers or gill teeth.

Barbel to end of bulb about one-third of standard length; to end of longest terminal filament about two-fifths of standard length. Barbel stem pale until just before distal bulb, very sparse melanophores on core for the entire length. Terminal bulb small, dark anteriorly (ventrally), pale posteriorly (dorsally), with three sets of terminal appendages: anterior appendages a pair of slender stems, pigmented on the anterior side, and bearing small internal spheres in the pigmented area, each stem with a distal swelling almost as large as the main bulb, and bearing several terminal ornaments as depicted in Fig. 1; middle appendages shorter than anterior, simple, slender, unpigmented stems with internal spheres, ending in slight elliptical swellings; posterior appendage arises as a short, single stem with pigmented core which branches into a pair of long, slender, tapering filaments, longer than the other bulbar appendages.

Pectoral fins with three rays, the medial one separated slightly more from the lateral two than these are from each other. Pelvics seven-rayed, extending almost to anal origin. Dorsal fin with 22 rays, its origin well behind that of the anal, which has 34 rays. Caudal with 5 procurrent and 9 principal rays in

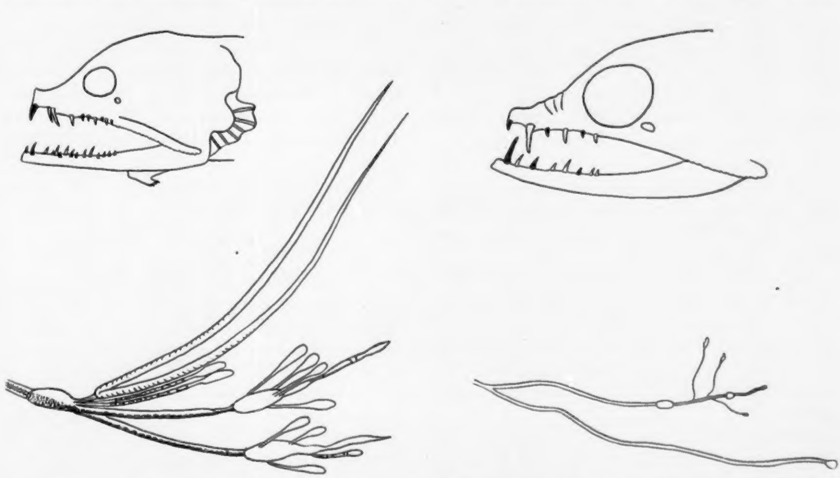

Fig. 1.—Left: lateral aspect of head and end of barbel. Left: *Eustomias bulbornatus*; right: *E. bifilis*. From the holotypes. Black teeth are fixed; white ones depressible.

both dorsal and ventral lobes. All fins pale, their rays lined on both sides with luminous material.

Main ventral and lateral series of photophores evenly spaced, not in pairs, the numbers as follows: IP 8, PV 33, VAV 18, OV 34, VAL 19, AC 18. Small photophores scattered over most of body and head.

Coloration of entire animal dark brownish-black, the trunk and tail crossed by narrow, dark, vertical lines extending from dorsum to median ventral line, i.e., continuous around body.

Measurements (all in mm.): standard length 95.8; snout to dorsal origin 80.6; snout to anal origin 71.2; snout to pelvic insertion 54.9; head length 12.1; barbel length to end of distal bulb 32.9, to end of longest distal appendage 38.1; snout length 3.3; bony orbit length 3.7; upper jaw length 9.8; greatest body depth 6.6.

Eustomias bifilis sp. nov.

Holotype.—SIO 54–96. Eastern Pacific west of Baja California, 24°35.5′N, 121°17′W to 24°42′N, 121°17′W, 0–103 fathoms, June 24, 1954, 10-foot midwater trawl, "S. F. Baird", R. L. Wisner and party; standard length 160.5 mm. This is the only known specimen.

Comparative Diagnosis.—A species of *Eustomias* with three pectoral rays and a barbel which has a main stem ending in a single bulb and has a long single branch with a distal bulb and a branched terminal filament. No known species of *Eustomias* displays such a barbel structure. Species with branches either have a single short one, or three. Superficially, the barbel of *E. tenisoni* Regan and Trewavas, 1930, appears somewhat similar, but in that species there are two additional side branches, albeit very small, the main bulb bears terminal appendages, the bulb of the branch has only a single short appendage, and, most significant, there are seven pectoral rays.

This new species, then, like *E. bulbornatus,* shows no close relationship to any known species. It cannot easily be fitted into any of the subgenera used by Regan and Trewavas (1930). Indeed, it is a further argument for suspension of the use of subgenera in this genus.

Description.—Body long, slender, the depth behind the head about 17 in standard length (stomach distended, this depth about 12). Head about 9 in standard length, the snout protractile. Bony orbit 2.5 in head, considerably longer than snout, which is about 4.5 in head. Postocular organ much smaller than eye, about one-fifth of fleshy orbit diameter. Premaxillary teeth 6 on left side, the second fang longest, the first, third, and fifth fixed, others depressible. Mandibular teeth 8 on left side, the first, third, and sixth fixed, the remainder depressible. No vomerine or palatine teeth. Two pairs of basibranchial teeth. No gill rakers. Pharyngobranchial teeth well-developed, in two patches.

Barbel to end of bulb on longest branch two-fifths of standard length, the shorter branch arising at slightly less than two-thirds of the length; stem and branches unpigmented. Longest branch (main stem) ending in a single small distal bulb. Shorter branch with a distal bulb bearing a filament with three branches, each ending in a small swelling, the continuation of the axial filament with a small subterminal and very small terminal swelling.

Pectoral fins with three rays, about evenly spaced. Pelvics seven-rayed. Dorsal fin with 20 rays, its origin considerably behind that of anal fin, which has 34 rays.

Main ventral and lateral series of photophores evenly spaced, not in pairs, the numbers as follows: IP 7, PV 30, VAV 13, OV 29, VAL 14, AC damaged, at least 13.

Coloration of entire animal dark brownish black.

Measurements (all in mm.): standard length 160.5; snout to dorsal origin 137.0, snout to anal origin 116.6; snout to pelvic insertion 94.0; head length 17.6; barbel length to branch 40.0, length to end of bulb on longest (main) branch 63.1, length of shorter branch 17.6; snout length 4.0; bony orbit length 7.1; upper jaw length 15.7; depth of body behind head 9.6; depth at distended stomach 13.1.

Eustomias longibarba Parr, 1927

Two specimens of this species were examined in the Scripps Institution of Oceanography collections. One, SIO, H 52-309, 128.5 mm., was taken May 23, 1952, at 17°48′02″ to 17°42′05″N, 127°07′14″ to 127°15′07″W in the eastern Pacific. The second, SIO, H54-95, 133.5 mm., was taken June 23–24, 1954, at 23°05′N, 119°08′W to 23°23′N, 119°36′W, 0–1333 fathoms, also in the eastern Pacific. Both were captured in a ten-foot Isaacs-Kidd midwater trawl.

The species was previously known from several stations in the western Atlantic, including the mid-Atlantic east of Bermuda, off the Bahamas, and off Jamaica in the Caribbean Sea. Its presence in the eastern Pacific suggests that the well-known relationship between many species on the east and west coasts of Central America is also shared by some bathypelagic forms. Since the larvae of most stomiatoids apparently inhabit relatively shallow waters, this situation is not particularly surprising.

Melanostomias valdiviae Brauer, 1902

A single specimen in the Scripps collection, SIO, H51–375, 141.6 mm., was taken in a midwater trawl tow made northeast of the Hawaiian Islands at 31°54.3′ to 31°36.5′N, 152°21.6′ to 152°03.6′W, at 1790 fathoms, September 15, 1951. The barbel characteristics would place this specimen in Regan and Trewavas' (1930) species *M. melanocaulus,* but I consider this a synonym of *M. valdiviae* (*Fishes of the Western North Atlantic,* in process). The species was described from just west of Sumatra in the northeastern Indian Ocean, and has been taken several times in the Atlantic.

Melanostomias biseriatus Regan and Trewavas, 1930

The single specimen reported here was placed at my disposal by William Aron of the University of Washington, in which collection the species resides. It was taken on July 18, 1958 between the hours of 0307–0403, at 38°55.7′N, 137°36.9′W, in the eastern Pacific, at 225 meters, using a modified 6-foot version of the Isaacs-Kidd midwater trawl. The barbel of this specimen is pigmented much as Regan and Trewavas' *M. biseriatus,* but has a terminal filament as in their *M. albibarba*. Examination of other specimens available to me indicates that those with a terminal filament are females, while one without it is a male. This fact, and the intermediacy of the barbel of this Pacific specimen, lead me to consider *M. albibarba* a synonym of *M. biseriatus.* The species was previously known from near the Azores, Bermuda, east of the Bahamas, and the Caribbean Sea.

Acknowledgments.—The examination of the specimen of *E. bulbornatus* was made possible through the courtesy of Leonard P. Schultz, Ernest A. Lachner, and Robert H. Kanazawa of the U.S. National Museum. *E. bifilis* and other Pacific specimens were studied at the Scripps Institution of Oceanography, where Carl L. Hubbs, Alfred W. Ebeling, and Richard Krejse provided every courtesy during my visit. William Aron of the Department of Oceanography, University of Washington, kindly allowed me to study the specimen of *M. biseriatus,* which was collected as part of a study supported in part by the Office of Naval Research (Contract Nonr-477(10)) and in part by the National Science Foundation.

Literature Cited

Brauer, A. 1902. Diagnosen von neuen Tiefseefischen, welche von der Valdivia-Expedition gesammelt sind. *Zool. Anz. 24:277–98.*

Parr, Albert E. 1927. The stomiatoid fishes of the suborder Gymnophotodermi. *Bull. Bingham Oceanogr. Col. 3(2):1–123.*

Regan, C. Tate and Ethelwynn Trewavas. 1930. The fishes of the families Stomiatidae and Malacosteidae. *Dana Exp. 1920–22 Rep. 6:1–143.*

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The Sensory Canals of the Head in Poeciliid Fishes (Cyprinodontiformes), with Reference to Dentitional Types.

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THIS work was suggested to us by casual observations of a relation between the development of the cephalic canal system and the character of the marginal jaw teeth in poeciliid fishes. The desirability of undertaking this work was enhanced by Gosline's (1949) findings that the head canals in vari-

[1] Work done under a National Science Foundation Post-doctorl Fellowship, 1959. Research on this project was conducted at an address other than that given at the end of the article.

ous cyprinodont groups are of systematic value. The results of his paper prompted us to look for a possible relation between the cephalic canals and feeding behavior in a variety of unrelated poeciliid species.

The following abbreviations are used: Academy of Natural Sciences of Philadelphia (ANSP), Chicago Natural History Museum (CNHM), Louisiana State University, Museum of Zoology (LSU), Museum of Comparative Zoology, Harvard College (MCZ), private collection (PC), Stanford University, Natural History Museum (SU), United States National Museum (USNM), University of Miami Fish Collection (UMFC), and Museum of Zoology, University of Michigan

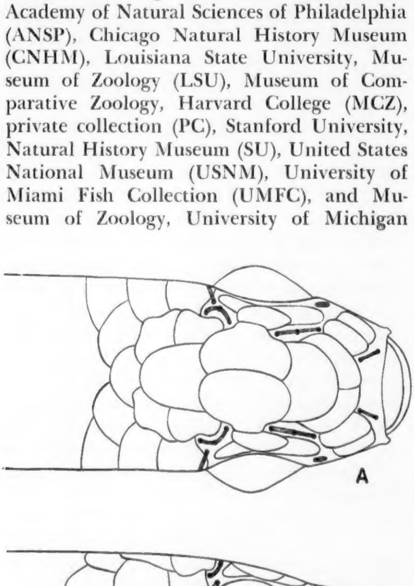


Fig. 1.—Diagram representing maximum development of the cephalic canals (stippled) and pores (solid) in relation to the head scales in a typical poeciliid fish. A. Dorsal. B. Lateral. C. Ventral.

(UMMZ). The authors are indebted to these institutions for the loans of specimens.

Materials

Brachyrhaphis olomina USNM 92154. *Gambusia affinis* LSU 6363, 6390. *G. dominicensis* USNM 78247, 88328; SU 39325. *G. geiseri* UMMZ 120358, 166018. *G. gracilior* USNM 104338. *G. howelli* SU 32021, 41658. *G. nicaraguensis* UMMZ 143587. *G. nobilis* SU 35962. *G. oligosticta* USNM 104339. *G. panuco* LSU 6298. *G. punctata* MCZ 33701, 33992. *G. senilis* SU 9401; UMMZ 166721. *G. vittata* LSU 6313. *Belonesox belizanus* UMMZ 144173. *Girardinus microdactylus* UMFC. *Pseudoxiphophorus bimaculatus* UMMZ 144225. *Poeciliopsis infans* SU 47631. *Priapichthys annectens* ANSP 45379-90. *Poecilia vivipara* SU 22119. *Micropoecilia parae* PC. *Limia caudofasciata* UMFC. *L. dominicensis* UMFC. *L. melanonotata* UMFC. *L. nigrofasciata* PC. *L. ornata* UMFC. *L. versicolor* UMFC. *Mollienesia formosa* UMMZ 157340. *M. latipinna* UMMZ 138424, 163388. *M. latipunctata* MCZ 39586 *M. petenensis* UMMZ 146634. *M. sphenops* MCZ 39580, 39591; UMMZ 159299. *M. velifera* UMMZ 143099. *Xiphophorus couchianus* UMMZ 97571. *X. helleri helleri* SU 22338. *X. helleri güntheri* PC(GC3); PC(GC11); PC(GC8). *X. maculatus* PC(BH); UMMZ 124261. *X. montezumae cortezi* PC. *X. montezumae montezumae* PC; SU 6146; LSU 6262. *X. pygmaeus nigrensis* PC(RGG7). *X. pygmaeus pygmaeus* PC(RGG8). *X. variatus* PC(GAW38); PC (GAW39); PC(GAW44); PC(GAW45); PC (GAW46). *X. variatus xiphidium* UMMZ 124416. *Phalloceros caudimaculatus* CNHM 55886; PC(SA2); PC(SA3); PC(SA4); PC (SA19); PC(SA17). *Cnesterodon decemmaculatus* PC. *Tomeurus gracilis* PC.

The method of studying head canals is that outlined by Gosline (1949).

Discussion

In its most developed form the cephalic canal system of poeciliids includes the maximum number of pores that has been recorded for a cyprinodont. Typically, the system is divided into seven distinct components (Fig. 1); two discontinuous sections of the supraorbital canal (pores 1 and 2a; pores 2b, 3 and 4a), two discontinuous sections of the posterior remnant of the infraorbital system (4b, 5 and 6a; 6b and 7), a preopercular canal with 7 pores, a preorbital section

with 4 pores, and a mandibular canal with 4 pores (sometimes continuous with an anterior groove). Not one case has been found, however, in which all of these canals were developed in a single individual. Moreover, most poeciliids have the canals represented as open grooves in contrast with other cyprinodonts. The canals are most developed in *Poecilia* and its allies although the infraorbital section is almost universally absent. Gosline (1949) did not record the mandibular canal in this family, but sections of it (usually 2 pores) do occasionally appear, and a single extremely large male *Xiphophorus helleri güntheri* showed a complete canal (4 pores).

Of the 15 genera represented in this study, all of the members of 3 (*Tomeurus, Gambusia* and *Belonesox*) have firmly rooted, conical, pointed teeth and completely undeveloped cephalic canals. In *Pseudoxiphophorus, Brachyrhaphis,* and *Priapichthys* the supraorbital canal and the upper portion of the infraorbital canal are typically undeveloped, and the marginal jaw teeth are large, firmly rooted and pointed. In *Xiphophorus* and *Poeciliopsis* (and in *Phallichthys* and *Carlhubbsia,* see Rosen and Bailey, 1959) the supraorbital system may be opened or closed depending upon size of individual, the infraorbital section open, and all other canals except the mandibular closed over; jaw teeth in these genera are mostly small, movable and flattened distally. In *Poecilia, Limia* and *Mollienesia* all but the upper portion of infraorbital system (pores 4b, 5 and 6a) are uniformly closed and jaw teeth in the members of these and related groups are weak and movable. Representatives of two other genera, *Micropoecilia* and *Phalloceros,* typically lack even a trace of the canals, but their teeth are small, movable, and incisor-like or spatulate. These fishes are small, however, and Gosline (1949) and Rosen and Bailey (1959) have shown that closure of the canals is most complete in larger individuals and species.

If *Tomeurus, Gambusia, Belonesox, Pseudoxiphophorus, Brachyrhaphis,* and *Priapichthys,* all of which have strong, conical teeth, are primarily carnivores, then the predatory habit appears to be correlated with the absence of closed canals (Figs. 2–3). Conversely, a greater development of the cephalic canals

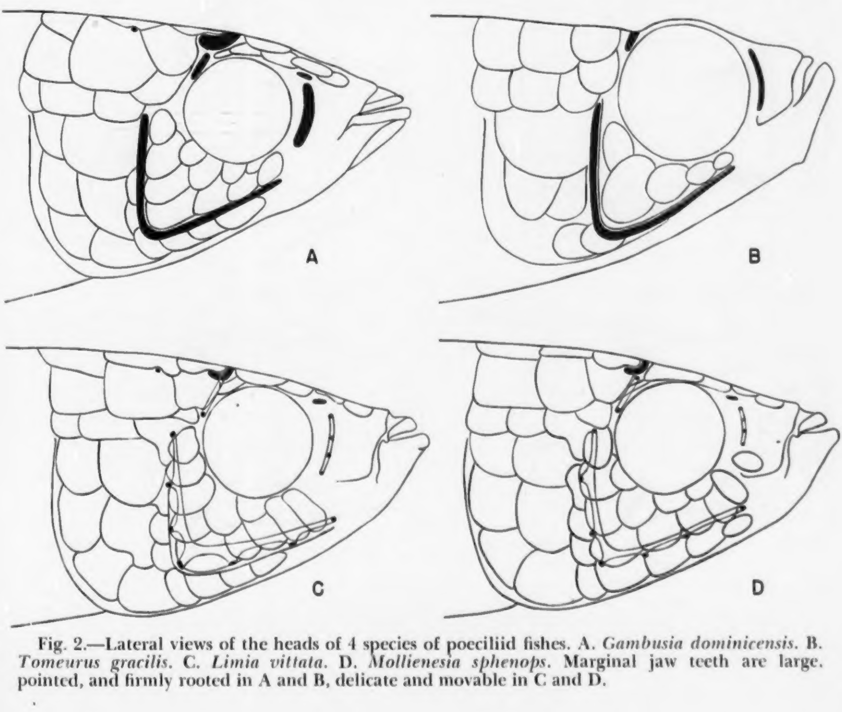
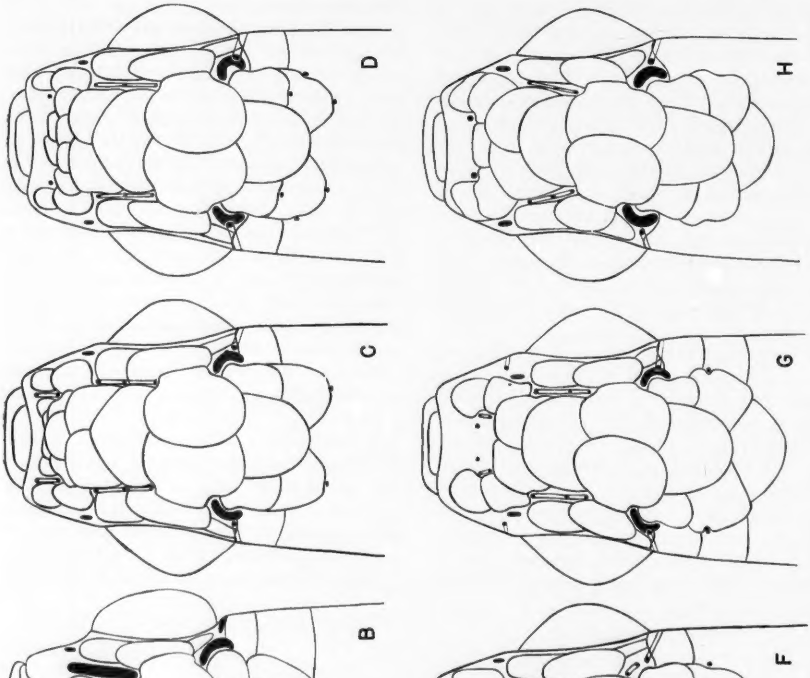


Fig. 2.—Lateral views of the heads of 4 species of poeciliid fishes. A. *Gambusia dominicensis.* B. *Tomeurus gracilis.* C. *Limia vittata.* D. *Mollienesia sphenops.* Marginal jaw teeth are large, pointed, and firmly rooted in A and B, delicate and movable in C and D.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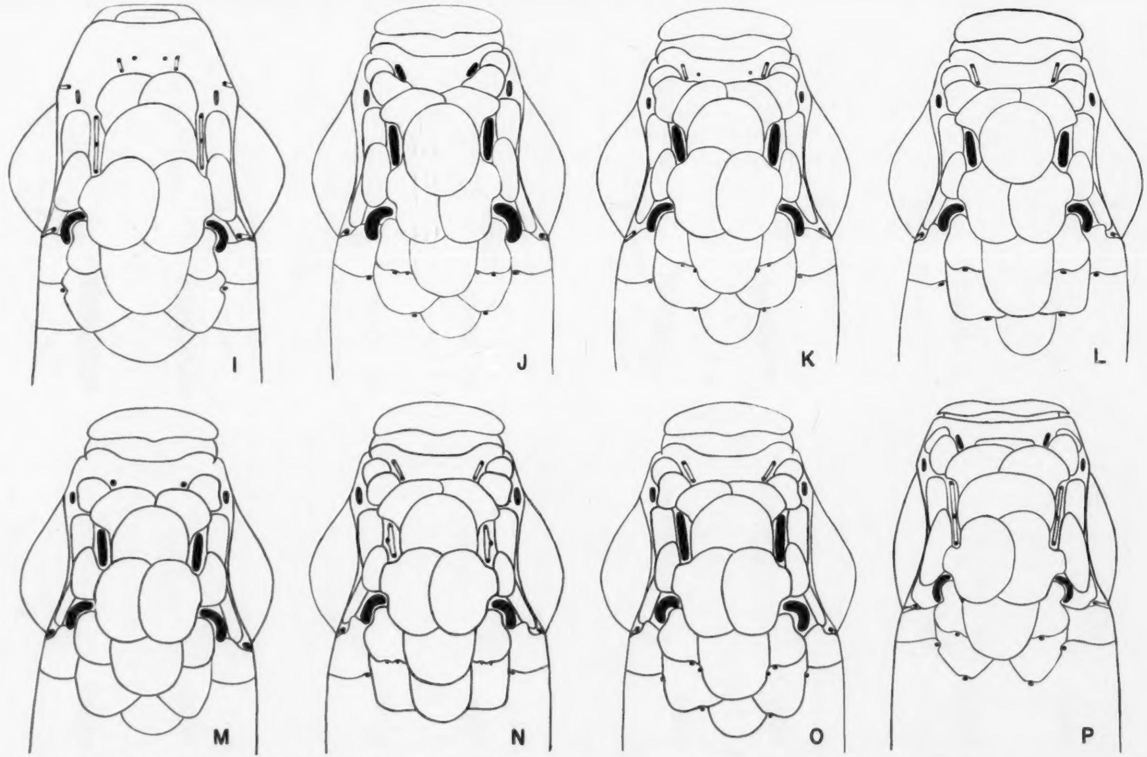
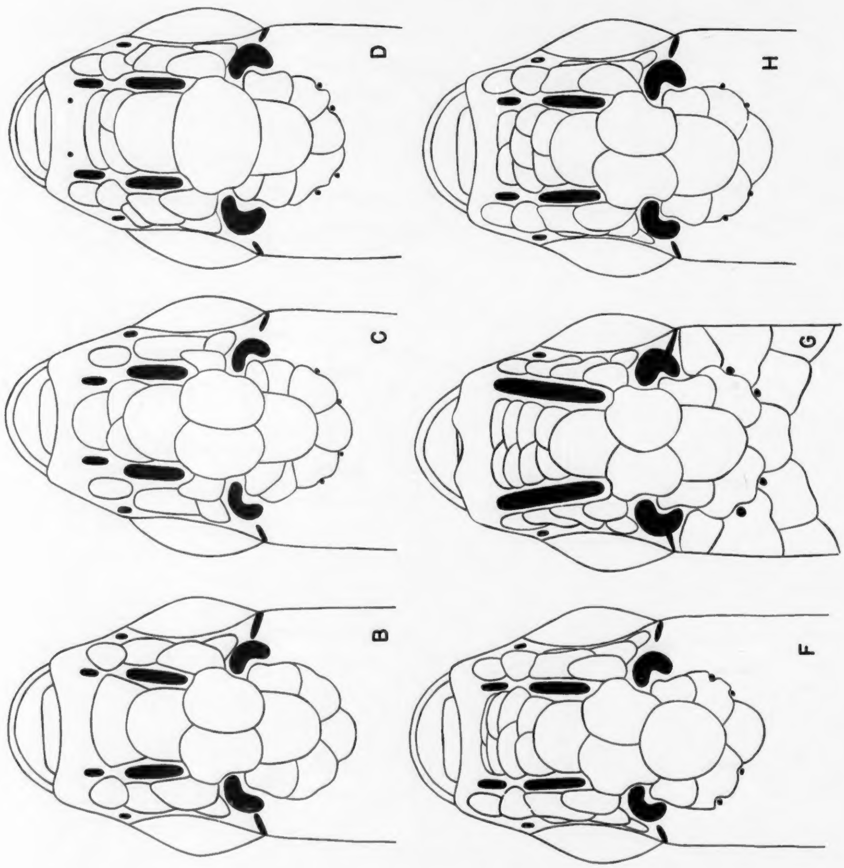


Fig. 3.—Dorsal views of the heads of 16 forms of poeciliid fishes that have moderately to well-develoqed cephalic canal systems and delicate, movable marginal jaw teeth. A. *Poecilia vivipara*. B. *Micropoecilia parae*. C. *Mollienesia sphenops*. D. *M. latipunctata*. E. *M. latipinna*. F. *M. velifera*. G. *Limia vittata*. H. *L. caudofasciata*. I. *L. ornata*. J. *Xiphophorus maculatus*. K. *X. v. variatus*. L. *X. m. montezumae*. M. *X. p. pygmaeus*. N. *X. helleri güntheri*. O. *X. h. helleri*. P. *Girardinus microdactylus*.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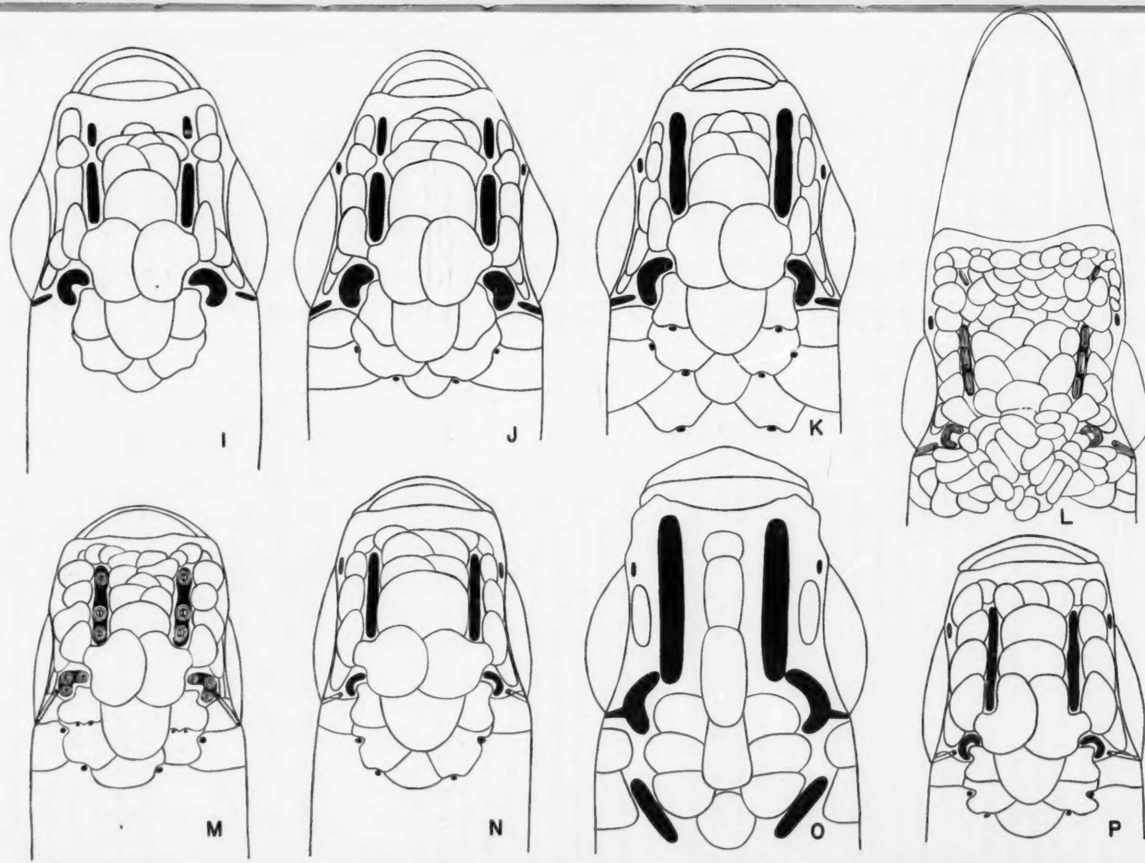

Fig. 4.—Dorsal views of the heads of 16 species of poeciliid fishes that have moderately developed or no cephalic canals and large, conical, pointed, and firmly rooted marginal jaw teeth. A. *Gambusia affinis*. B. *G. geiseri*. C. *G. nobilis*. D. G. *senilis*. E. *G. panuco*. F. *G. nicaraguensis*. G. *G. punctata*. H. *G. howelli*. I. *G. oligosticta*. J. *G. gracilior*. K. *G. dominicensis*. L. *Belonesox belizanus*. M. *Pseudoxiphophorus bimaculatus*. N. *Brachyrhaphis olomina*. O. *Tomeurus gracilis*. P. *Priapichthys annectens*. Positions of exposed neuromasts are shown in L and M.

may be a characteristic of most omniverous feeders (Figs. 2 and 4).

Although the above conclusions may be valid for Poeciliidae in general, they certainly can not be broadly applied to many other cyprinodontiforms. The species of *Fundulus,* for example, have both powerful jaw teeth and an extremely well developed cephalic canal system.

Lowenstein (1957) believed that the lateralis system of fishes is chiefly concerned with orientation to distant objects. Such objects may be moving, and thus detectable as the focal point of a mechanical disturbance, or they may be stationary, and sensed by some form of echo-location. He reasoned that the canal systems are best developed as a protective covering for the neuromasts in fishes that are continually exposed to the action of relative water movements, for example, in free-swimming forms. Bottom living and sedentary fishes, he observed, frequently have the canals secondarily reduced and represented by free sensory hillocks.

The presently observed close correlation between development of the sensory canals of the head and dentitional types in Poeciliidae suggests that the cephalic canals (but not the lateralis system as a whole) are somehow employed by these fishes in feeding. Field and laboratory observations reveal that many fishes with open canals and strong teeth are predominantly surface feeders and that those with closed canals and movable teeth forage a good deal on the bottom. Opening of the canals exposes the neuromasts directly to the environment. Thus a carnivore moving about at the surface would have its exposed neuromasts almost if not in contact with the surface film. Disturbances on the surface caused by trapped insects would probably be sensed more rapidly than if the canals were closed over. Exposed neuromasts, however, may provide a means of rapid sensing of vibrations whether at the surface or below and be especially suited to the rapid location by a carnivore of its prey.

Literature Cited

GOSLINE, A. 1949. The sensory canals of the head in some cyprinodont fishes, with particular reference to the genus *Fundulus. Occ. Papers Mus. Zool. Univ. Michigan, No. 519. 17 pp.*

LOWENSTEIN, O. 1957. The acoustico-lateralis system. Pp. 155–186, in Vol. 2, *The Physiology of Fishes,* Brown, Ed., *Acad. Press Inc., New York.*

ROSEN, D. E. AND R. M. BAILEY. 1959. Middle-American poeciliid fishes of the general *Carlhubbsia* and *Phallichthys,* with descriptions of two new species. *Zoologica, 44(1):1–44.*

FLORIDA STATE MUSEUM AND DEPARTMENT OF BIOLOGY OF THE UNIVERSITY OF FLORIDA, GAINESVILLE, AND INDIANA UNIVERSITY, BLOOMINGTON.

Description of a Western Atlantic Specimen of *Scombrolabrax heterolepis* Roule and Notes on Fishes of the Family Gempylidae

MARION GREY

THE fishes reported here were all caught during recent voyages of the United States Fish and Wildlife Service research vessel *Oregon.* The figures were prepared by Miss Marion Pahl.

Scombrolabrax heterolepis Roule

One specimen, total length 200 mm., fork length ca. 176 mm., standard length 165 mm., Station No. 2191, Gulf of Mexico, 25°11′N., 89°50′W., 23 May 1958, 41-foot midwater trawl hauled at a depth of 75–85 fathoms (137–155 meters), bottom depth 1800 fathoms (3292 meters).

Description.—Dorsal XII, 14 or 15, spines concealed in a groove, first seven connected by membrane, last five short, broad-based, not attached to one another. Anal II, 18. Pectoral 18. Ventral I, 5. Lateral line 44 on left side, 46 on right side.

Measurements in mm., followed in parentheses by percent of the standard length: head 56 (33.9); depth 40 (24.2); snout 15.5 (9.4); orbit 17 (10.3); interorbital width at

center of eye 12 (7.28); upper jaw 26.5 (16.05); tip of snout to dorsal origin 66 (40.0), to anal origin 112 (67.9), to upper angle of pectoral base 55.5 (33.8), to ventral base 58.5 (35.4); upper angle of pectoral base to ventral base 20 (12.1); distance between ventral base and anus 47.5 (28.8), ventral base and first anal spine 53 (32.1), first anal spine and end of body 52 (31.5), last anal ray and end of body 20 (12.1), last dorsal ray and end of body 23 (13.9); base of second dorsal fin 27 (16.35); third (longest) dorsal spine 19 (11.5); third (longest) dorsal ray 18 (10.9); anal base 31 (18.8); longest anal rays (second and third) 17 (10.3); pectoral length 57 (34.5); ventral length 21 (12.7); least depth of caudal peduncle ca. 13 (ca. 7.88).

Body compressed, tail short; general appearance rather like that of *Epinnula* Poey. Origin of dorsal fin above posterior (lower) end of pectoral base. Anal origin directly below origin of second dorsal, spines short, not free, first one 1.5 mm., second one 3.5 mm. in length. Pectoral fin very long, reaching anal origin. Ventrals directly below pectoral bases.

Scalation as described in type specimen, extending on lower bases of caudal, soft dorsal and anal fins; scales moderately deciduous, mostly lost on head and on right side of tail; irregular in size and somewhat so in shape, usually roundish but some on anal base elongate. Lateral line single, close to dorsal profile, commencing above upper end of gill opening and ending below seventh or eighth dorsal ray; the scales enlarged, regular in size and shape; a longitudinal arched area in center of each scale; a distinct notch on posterior edge of each, exposing a half-tube in the skin below; and a deeper notch on the anterior edge of each scale, this notch hidden beneath preceding scale; on under side of each scale, corresponding to rounded central portion of scale as seen from above, a pair of ridges, center of scale thus forming roof of half tube in skin (Fig. 1).

Head large, eye very large, interorbital region flat. No cartilaginous projections on jaws. Upper jaw nearly reaching a vertical from end of pupil. Supramaxillary long and slender, similar to that of *Epinnula magistralis* Poey from Japan, as figured by Matsubara and Iwai (1958:29, fig. 3D). Angle and lower limb of preopercle serrated, lower half of opercular edge more finely serrated, upper margin of opercle with four pointed projections, the lowermost the largest.

A single long, curved tooth anteriorly on each premaxillary, followed by a row of 13 much smaller teeth. Lower jaw with a row of seven or eight teeth on each side, larger and heavier than those of upper jaw (excepting fangs), the two anterior ones smaller, the fourth or fifth the largest. Vomer with one small tooth on each side. No teeth visible on palatines but examination under magnification reveals one minute tooth on anterior end of palatine on one side only. No teeth on tongue.

First gill arch with four well developed denticulate gillrakers and one rudimentary one, longest in angle, others on lower limb; upper limb with ten clusters of minute spines, scarcely raised above surface of bone. Inner edge of first arch with five short teeth on lower limb, none in angle, the one nearest angle double; and four short teeth on upper limb. Pseudobranchiae well developed.

Color uniform blackish brown, including fins. Inside of mouth and gill covers black.

Remarks.—The present specimen differs slightly from the type, as shown in Table 1, but the consistently higher percentages found in the western Atlantic fish could well be the result of a difference in the method of measuring the standard length. At any rate, a number of specimens from both the eastern and the western Atlantic would be needed to establish specific or racial differentiation. It should be noted that although Roule (1922:5, fig. 1) wrote that the scales of the lateral line

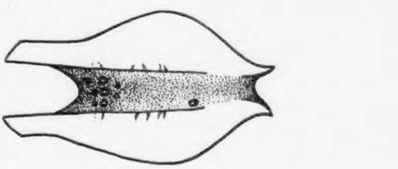

Fig. 1.—Lateral line scales of *Scombrolabrax heterolepis*. Upper figure, lower surface of scale removed from body. Lower figure, three scales *in situ*.

TABLE I
COUNTS AND PROPORTIONS OF
Scombrolabrax heterolepis

	Roule, 1922	Arté, 1952	Oregon
Dorsal rays	VI + VI + I, 14	VII+ V + 15	VII + V + 14–15
Anal rays	I, 15	II, 16	II, 18
Pectoral rays	17	19	18
Ventral rays	I, 5	I, 5	I, 5
Scales in lateral line	48–50	—	44–46
Standard length	227	—	165
	Percent of standard length		
Depth	21.1	—	24.2
Head	31.5	—	33.9
Snout	8.36	—	9.4
Orbit	8.8	—	10.3
Interorbital width	6.61	—	7.28
Tip of snout to:			
dorsal origin	41.0	—	40.0
anal origin	71.3	—	67.9
Pectoral length	33.9	—	34.5
Ventral length	12.3	—	12.7
Least depth of caudal peduncle	7.95	—	ca. 7.88

did not differ from those of the rest of the body, the figure shows them to be of uniform size and shape. The lateral line scales of the type should be re-examined to determine whether they are identical with those of the present specimen.

Scombrolabrax Roule

The genus *Scombrolabrax* was based on a single specimen caught by fishermen at Madeira in a depth of 800–900 meters and until now has been found only once again, off northern Spain in no more than 110 meters (Arté, 1952). It was placed originally in a separate family, Scombrolabracidae ("Scombrolabracidés"), and suborder, "Scombropercoïdes" (Order Percomorphi) (Roule, 1922), and was said to have characters of both the Scombropidae and the Gempylidae. Subsequently the genus has been classified, without comment, with the families Gempylidae (Norman, *Zool. Rec.* for 1922; Palmer, *Zool. Rec.* for 1952), Apogonidae (Jordan, 1923: 189) and Amiidae (Fowler, 1936:732, 737; Arté, 1952:102). In 1929 Roule again mentioned the species, at that time referring to it as a "Gempylidé monstreux" and indicating its closest "normal" relative to be *Epinnula* Poey. Roule's remarks on teratology require no comment but it must be agreed that *Scombrolabrax* bears a distinct resemblance to *Epinnula* in body form.

The purpose of the present report is merely to call attention to the existence of this species in the western Atlantic. Although my inclination is to consider *S. heterolepis* the sole representative of a distinct family, it would be unwise to make a positive statement to this effect without more thorough study. The general appearance of the fish instantly aligns it with the Gempylidae but the long pectoral fin and the form of the first dorsal fin are not characteristic of this family. Some characters of *S. heterolepis* would be considered primitive if it were to be placed in the Gempylidae, or non-gempylid if it were to be excluded from the family. Such characters are the presence of four well developed gillrakers on the first arch and serrations on the margins of the opercle and preopercle, the vertebral count of 14 + 16 = 30 (Roule, 1922), and the structure of the lateral line scales. The ridges on the underside of the latter appear to be a primitive form of the typical gempylid lateral line scale, on which there is a complete tube. Irregularity in the size and shape of the body scales is not unknown in gempylids as Roule supposed, and furthermore within the family as presently defined the scalation varies widely.

Family Gempylidae

A comparison of the fish described above with several gempylid genera has resulted in the discovery of a few hitherto unrecognized characters, one of which more or less nullifies portions of the key published by me in 1953. Young specimens of *Nesiarchus nasutus* Johnson from Bermuda (295 and 287 mm. in standard length) have a few teeth on the palatine bones, which were said in the key to be edentulous. Adults do not have palatine teeth. Palatine teeth were found also on several small specimens of *Rexea solandri* (Cuvier and Valenciennes) from Japan, their standard length 152–204 mm. Matsubara and Iwai (1958:32, fig. 4F) described and figured the palatine bones of this species as toothless (from specimens 125–215.5 mm. in standard length) although earlier (1952:204) the same authors had mentioned teeth on the palatine bones of *R. solandri*. Numerous small teeth are present also on the tongue of *Rexea*; and

specimens of *Promethichthys prometheus* (Cuvier and Valenciennes) from both the western Atlantic and Hawaii were found to have on the tongue two lengthwise rows of circular patches of extremely minute teeth, visible only under a microscope. The tongue is apparently toothless in *Nesiarchus* and in *Neoepinnula*. The only reference in the literature to tongue teeth on a gempylid was in the description of a specimen of *Thyrsitoides marleyi* Fowler from South Africa: "Tongue covered with minute teeth." (Smith, 1937). It should also be mentioned that the vomerine teeth of *Neoepinnula* are sometimes minute and all but invisible.

Nesiarchus has no gillrakers evident to the naked eye, although magnification reveals a subcutaneous series of clusters of minute spines on the first gill arch. The scales of this genus are similar to those of *Scombrolabrax* —small, thin, cycloid, varying slightly in size but to a lesser degree than in *Scombrolabrax*, and with some along the anal base enlarged and elongate in shape.

The basic structure of the lateral line scales of *Neoepinnula, Rexea, Promethichthys* and *Nesiarchus* is the same although these scales differ in shape on different species. Matsubara and Iwai (1958) described and figured the lateral line scales of gempylid genera as tubular but of the four examined by me only those of *Rexea* appear to be tubular in the strict sense of the word. In *Neoepinnula* and *Nesiarchus* the longitudinal tube occupies almost the entire central area but the scale also extends above and below the tube. It is very thin in these areas, is difficult to see *in situ*, and has a tendency to curl downward when removed from the skin. The upper and lower portions of the lateral line scales are overlapped by small body scales and this is also true of *Promethichthys*. In the latter the scales of the posterior portion of the lateral line may consist only of the tube but anteriorly there is a slight but distinct broadened area on the posterior edge of each scale. The scales are more fragile in *Promethichthys* than in other genera examined.

It is of interest that the shape of the lateral line scales differs in the two forms of *Neoepinnula orientalis* at hand. The portions of each scale above and below the tube are noticeably broader in *N. o. americana* (Fig. 2) and in shape the scales of this form are similar to those of *Scombrolabrax*. The more elongate form of the lateral line scales of *N. o. pacifica* (Fig. 3), with the tube occupying a greater portion of the scale area, more closely resembles that of the lateral line scales of *Nesiarchus*.

The genus *Neoepinnula* Matsubara and

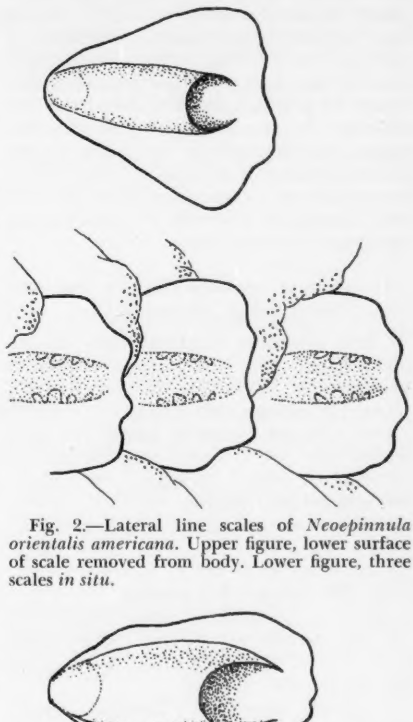

Fig. 2.—Lateral line scales of *Neoepinnula orientalis americana*. Upper figure, lower surface of scale removed from body. Lower figure, three scales *in situ*.

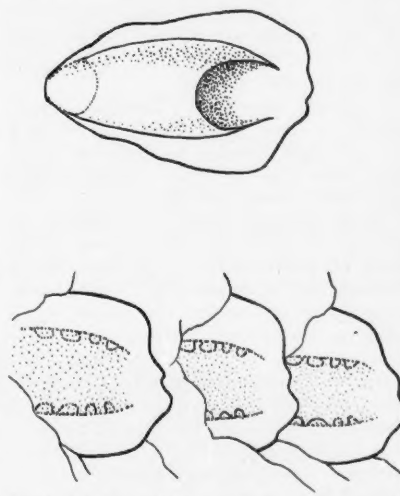

Fig. 3.—Lateral line scales of *Neoepinnula orientalis pacifica*. Upper figure, lower surface of scale removed from body. Lower figure, three scales *in situ*.

Iwai is provisionally accepted as distinct from *Epinnula* Poey. According to Matsubara and Iwai (1958) a number of characters require the separation of these two genera but most of these characters seem to me to be of specific rather than generic value: position of origin of second lateral line; length of ventral fin; dorsal origin; presence or absence of vomerine teeth (which are sometimes minute and all but invisible in *Neoepinnula*); color; length of gillraker. On the other hand, the difference in the structure of the lateral line scales, the spination on the inner surface of the gillraker of *Neoepinnula* (smooth in *Epinnula*) and the spination of the preopercular margin of *Epinnula* do indicate that two genera actually exist.

Neoepinnula orientalis Gilchrist and von Bonde subsp. *americana* Grey

Three specimens, standard length 125–265 mm., Station No. 1868, western Caribbean Sea, 16°36′N., 82°37′W., 21 August 1957, trawl, 175 fathoms (320 meters).

One specimen, standard length 104 mm., Station No. 1885, western Caribbean Sea, 16°54′N., 81°18′W., 23 August 1957, trawl, 250 fathoms (457 meters).

One specimen, standard length 200 mm., Station No. 2083, off northern South America, 01°49′N., 46°48′W., 17 November 1957, trawl, 225 fathoms (411 meters).

Eighteen specimens, standard length 115–142 mm., Station No. 2651, off Puerto Rico, 18°16.5′N., 67°17′W., 6 October 1959, trawl, 250 fathoms (457 meters).

Seventeen specimens, standard length 166.5-ca. 250 mm. (largest specimen 305 mm. in total length), Station No. 2658, off Puerto Rico, 18°25.5′N., 67°14′W., 6 October 1959, trawl, 250 fathoms (457 meters).

These specimens extend the range of *N. orientalis* to the Caribbean Sea and the Atlantic off Puerto Rico and northern South America. The distribution will undoubtedly prove to be still wider. The known depth range in the western Atlantic is 184–457 meters.

One of the specimens from Station 2658 is larger than any hitherto reported. Its total length is 305 mm., standard length 250 mm. It is also deeper-bodied than any specimen previously seen and the greatest depth is situated more posteriorly, at the origin of the second dorsal and anal fins. The depth of this specimen is 26.0 percent of the standard length. In specimens reported by me in 1953 the depth ranged from 21.4 to 23.9 percent of the standard length (137.5–220 mm.) and in a very young specimen of 86 mm. (Grey, 1959:342) the depth was only 17.4 percent of the standard length. Thus, in addition to a backward migration of the region of greatest depth during growth, the species appears also to become deeper bodied with age.

The arrangement of the pores in the lateral line scales, the spination of the gillrakers, the shape of the supramaxillary bone, as well as the form and size of the liver and of the pyloric caecae agree well with descriptions of Japanese specimens of *N. orientalis* published in 1958 by Matsubara and Iwai.

Promethichthys prometheus (Cuvier and Valenciennes)

One specimen, standard length 215 mm., Station No. 2007, off northern South America, 07°34′N., 54°49′W., 7 November 1957, trawl, 225 fathoms (411 meters).

Two specimens, standard length 224 and 213 mm., Station No. 2008, off northern South America, 07°38′N., 54°43′W., 7 November 1957, trawl, 250 fathoms (457 meters).

One specimen, standard length 246 mm., Station No. 2082, off northern South America, 01°51′N., 46°50′W., 17 November 1957, trawl, 200 fathoms (366 meters).

One specimen, standard length 231.5 mm., Station No. 2652, off Puerto Rico, 18°62′N., 67°16.5′W., 6 October 1959, trawl, 230 fathoms (421 meters).

Previous western Atlantic reports of *P. prometheus* have been from Bermuda and the Gulf of Mexico. Anderson and Gehringer (1957:49, 51) tentatively identified with this species a specimen found in the stomach of a barracuda caught in the Atlantic off Florida (26°N.). The specimens reported here extend the range of the species to Puerto Rico and northern South America. In the western Atlantic *P. prometheus* has been caught at depths between 366 and 457 meters.

Literature Cited

Anderson, W. W. and Gehringer, J. W. 1957. Physical oceanographic, biological and chemical data. South Atlantic coast of the United States. *Gill* Cruise 4. *Spec. Sci. Rep. U.S. Dept. Int., Fish., 234:48–64.*

Arté, P. 1952. Notas ictiológicas 1. Peces raros o nuevos para el litoral gallego (N.W. de España). *Publ. Inst. Biol. Aplic., Barcelona, 10: 93–103, figs. 1–6.*

FOWLER, H. W. 1936. Marine fishes of West Africa. *Bull. Amer. Mus. Nat. Hist., 70:1493 pp.*

GREY, M. 1953. Fishes of the Family Gempylidae, with records of *Nesiarchus* and *Epinnula* from the western Atlantic and descriptions of two new subspecies of *Epinnula orientalis*. COPEIA, *1953:135–141.*

———. 1959. Deep sea fishes from the Gulf of Mexico, with the description of a new species, *Squalogadus intermedius* (Macrouroididae). *Fieldiana, Zool., 39:323–346, figs. 53–57.*

JORDAN, D. S. 1923. A classification of fishes. *Stanf. Univ. Publ., Univ. Ser., Biol. Sci., 3(2): 1–243.*

MATSUBARA, K. AND IWAI, T. 1952. Studies on some Japanese fishes of the family Gempylidae. *Pacific Sci., 6:193–212, figs. 1–12.*

———. 1958. Anatomy and relationships of the Japanese fishes of the family Gempylidae. *Mem. Coll. Agric. Kyoto Univ., Fish. Ser., Spec. No., pp. 22–54, figs. 1–14.*

ROULE, L. 1922. Description de *Scombrolabrax heterolepis* nov. gen. nov. sp., poisson abyssal nouveau de l'Ile de Madère. *Bull. Inst. Océanogr. Monaco, 408:1–8, figs. 1–4.*

———. 1929. Considérations sur la nature tératologique probable de quelques formes de poissons abyssaux. *10 Cong. Int. Zool., Budapest, 1927, 1: 795–798.*

SMITH, J. L. B. 1937. New records of South African fishes. *Ann. Natal Mus., 8:167–198, pl. 11, text figs. 1–6.*

CHICAGO NATURAL HISTORY MUSEUM, CHICAGO 5, ILLINOIS

A New Clingfish of the Genus *Gobiesox* from the Tres Marias Islands

JOHN C. BRIGGS

DURING the 1959 cruise of the H. R. MacMillan yacht "Marijean" to the tropical Eastern Pacific, a large rotenone collection of shore fishes was made by Dr. P. A. Larkin and Mr. M. W. McCutcheon at San Juanito Island, one of the Tres Marias group. When this lot was being sorted, in preparation for cataloguing in the U.B.C. collection, a series of 11 specimens were found which clearly represent an unknown species of *Gobiesox*.

This species is described following the uniform plan and sequence previously adopted (Briggs, 1955) for this order of fishes. The various counts and measurements were also taken in the manner described in that work.

Gobiesox marijeanae, sp. nov.

Figure 1

Diagnosis.—A *Gobiesox* with a poor development of papillae on head. Margin of upper lip smooth. Dorsal origin much closer to upper pectoral base than to caudal base. Anus located closer to anal fin origin than to rear margin of disc and under 8th (8–9) dorsal ray. Eye 1.2 (1.0–1.4) in bony interorbital space and 5.6 (4.7–7.3) in head. Each part of disc region C consists primarily of 3 longitudinal rows of papillae; there are 6 (6–7) rows across width of disc region A. In the adult, the tip of the depressed anal fin extends well posterior (about an eye's diameter) to that of the depressed dorsal fin. Dorsal rays 19 (17–20), anal rays 11 (10–12), pectoral rays 21 (21–22), and caudal rays 11 (10–11).

Description.—Body moderately depressed, depth 5.5 (5.2–5.8) in standard length. Caudal peduncle moderate, least depth 1.2 (1.1–1.3) in its length. Head well depressed, length 2.6

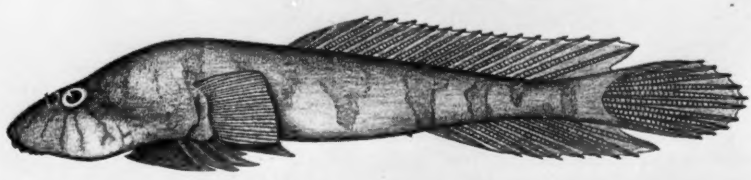

Fig. 1.—*Gobiesox marijeanae*, drawn from the holotype, 54 mm. in standard length, University of British Columbia, No. 59-270.

(2.5–2.7) and width 2.7 (2.6–2.8) in standard length. Snout shallow with lateral outline slightly rounded, 3.2 (2.9–3.6) in head. Posterior nostril directly above anterior edge of eye; anterior nostril with a medium, bilobed, dermal flap extending from its posterior margin. Teeth of lower jaw in two rows, those of the outer row much the larger; 6 (5–7) pairs of incisors at the front, rounded in the larger specimens and pointed in the smaller. These followed on each side by a row of canines. Teeth at front of upper jaw conical, forming a shallow patch, followed on each side by a row of slightly recurved canines. Nine (8–10) shallow rakers on each of the two posterior gill arches.

All papillae on head shallow, lobe-like structures, none on upper lip margin and none on snout above center of premaxillary groove. Upper attachment of gill membrane opposite 6th (6–7) pectoral ray. Subopercular spine well developed but covered by the skin of the opercle region. Fleshy pad on pectoral base conspicuous, with a free posterior margin extending from upper gill membrane attachment to lowest part of pectoral base. Upper attachment of axial dermal flap opposite 6th (6–7) pectoral ray. Dorsal-caudal distance forward extends to the tip of the snout or beyond; postdorsal-caudal distance 4.9 (4.6–5.2) in dorsal length. Length of disc 3.3 (3.2–3.4) in standard length. Depressed tip of anal fin extends well beyond a vertical line from caudal base.

Coloration.—In alcohol, the dorsal and lateral sides are blotched and spotted with various amounts of blackish pigment over a gray-white ground color. No definite pattern of melanophore distribution is discernable except on the head where black punctulations usually predominate and small, dark lines can be seen radiating from the eyes. The vertical fins are a uniform grey; this effect produced by an even distribution of small melanophores on the rays and interradial membranes. The pectoral fins are lighter with the membranes being mostly clear. The ventral body surface behind the disc is unusually heavily pigmented and considerable spotting can be seen beneath the chin and even on the surface of the disc.

Relationship.—The conical teeth at the front of the upper jaw, the complete free posterior margin on the fleshy pectoral pad, and the close proximity of the anus to the origin of the anal fin are characteristics which serve to indicate that *Gobiesox marijeanae* is a relatively advanced member of the genus. The extreme length of the dorsal fin, with 19 (17–20) rays, is shared by only two other known species. These are *G. pinniger* with 18 (16–19) dorsal rays and *G. schultzi* with 19 (18–20) rays.

Gobiesox marijeanae differs from *G. pinniger* in the absence of papillae on the upper lip margin, in the position of the anus which is very close to the anal fin origin rather than about midway between this point and the rear margin of the disc, and in the absence of the 4 or 5 light, vertical bars on the side posterior to the pectoral fin.

This new species is most closely related to *Gobiesox schultzi* but may be easily separated as follows: the tip of the depressed anal fin extends well posterior to that of the depressed dorsal fin instead of about the same distance, each part of disc region C is comprised primarily of 3 rather than 2 longitudinal rows of flattened papillae, and the length of the disc measures 3.3 (3.2–3.4) compared to 3.0 (2.8–3.1) in standard length.

Zoogeography.—The discovery of *Gobiesox marijeanae* in the Tres Marias is most interesting because its closest relatives, *G. pinniger* and *G. schultzi*, are apparently both confined to the Gulf of California. In fact, the closest of the two (*G. schultzi*) has not been taken south of Ceralbo Island which is well within the Gulf and some 275 miles north of the Tres Marias.

It is not likely that either *Gobiesox marijeanae* or *G. schultzi* occurs along the intervening mainland coast since this area has been quite heavily collected in recent years. It seems, therefore, that this new species is represented by an isolated population and probably stems from *G. schultzi* or a common ancestral form. The colonization from the mainland most likely took place when the surface temperature of the ocean was cooler than at present, allowing species now confined to the Gulf to range considerably further south. This distribution shows an interesting parallel to that of other species which have recently been found. For example, both *Gobiesox eugrammus* and *Rimicola sila*, which are Guadalupe Island endemics, are most closely related to species which occur on the California coast at some distance to the north. The same is true for *Tomicodon absitus* from Socorro Island in the Revilla Gigedo Archipelago. It is closest to *T. boehlkei*, another form now confined to the Gulf of California. Finally, there is *T. ver-*

miculatus from Cocos Island which is a cognate of *T. myersi* found, so far, only on the northern coast of Mexico.

Thus, it can be seen that the distributional relationship between *Gobiesox marijeanae* and *G. schultzi* fits and reinforces a pattern already demonstrated by certain other pairs of species in the same family.

As far as clingfishes are concerned, the Tres Marias Islands had previously been considered too close to the mainland shore for speciation to take place. Four species have been reported from these islands: *Arcos erythrops* and *Tomicodon eos eos* by Briggs (1955:70, 84) and *Gobiesox papillifer papillifer* and *Tomicodon petersi* by Ricker (1959: 14). These show little or no morphological evidence of genetic isolation. However, Clark Hubbs (1952:155) refers to two endemic blennys, one a species of tripterygiid and the other a subspecies of *Paraclinus mexicanus.*

Holotype.—University of British Columbia 59-270; 54.0 mm. in standard length, collected by P. A. Larkin and M. W. McCutcheon at San Juanito Island in the Tres Marias group on April 5, 1959.

Paratypes.—Chicago Natural History Museum 62806; one, 50.8 mm. in standard length. University of Michigan Museum of Zoology 175894; one, 48.2 mm. in standard length. Academy of Natural Sciences of Philadelphia 90849; one, 47.0 mm. in standard length. Stanford University 53184; one, 44.4 mm. in standard length. University of British Columbia 59-270; five, 10.8–37.0 mm. in standard length. United States National Museum 179685; one, 38.3 mm. in standard length. All paratypes were collected with the holotype.

Derivation of name.—Named *marijeanae* after the yacht "Marijean" in recognition for the many valuable fish collections which have been made during the cruises of this vessel to the tropical Eastern Pacific.

Remarks.—The discovery of this species serves to give further emphasis to the remarkable degree of evolutionary radiation shown by the genus *Gobiesox* in the Eastern Pacific and its freshwater tributaries. This is the 25th known Eastern Pacific species bringing the total known in the genus to 29. The remaining four species are found in the Western Atlantic and its freshwater tributaries.

Literature Cited

Briggs, John C. 1955. A monograph of the clingfishes (order Xenopterygii). *Stanford Ichthy. Bull., 6:iv + 1–224, 114 figs., 15 maps.*

Hubbs, Clark. 1952. A contribution to the classification of the blennioid fishes of the family Clinidae, with a partial revision of the Eastern Pacific forms. *Stanford Ichthy. Bull., 4(2):41–165, 64 figs., 2 maps.*

Ricker, Karl E. 1959. Mexican shore and pelagic fishes collected from Acapulco to Cape San Lucas during the 1957 cruise of the "Marijean". *Museum Contrib., Inst. Fisheries, Univ. British Columbia (3):1–18, 1 map.*

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Notes on the Freshwater Fishes of Sonora with an Addition to the Known Fauna[1]

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THE authors undertook a general collecting expedition to Sonora, Mexico, in August, 1959. With the exception of its southwestern tip this state is an extremely arid region most of the year. Since August is the rainy season, collecting is difficult for one unfamiliar with the intermittent nature of the streams. Seventeen species of fishes were taken in 10 streams, although collections were attempted in every body of water encountered. The authors are grateful to Dr. Robert R. Miller, University of Michigan, for helpful advice, to Dr. George A. Moore for assistance in determination of species and for reading the manuscript, and to Sr. Luis M. Arellano, Director General de Caza, Mexico City, for extending us the privilege of collecting in Sonora.

[1] Contribution #314 from the Department of Zoology and the Research Foundation, Oklahoma State University.

Collecting Stations

The freshwaters of Sonora can be divided into two main categories, temporary and per-

manent (with subdivisions in each). Temporary waters are not very productive. The only fish found was *Agosia chrysogaster*, and that in small numbers. Most specimens were found in turbid or clear permanent waters. The latter are not as productive as turbid waters, mainly because most of them are in the mountains and represent rain-water runoff. However, some of the clear waters originate from artesian wells and everflowing springs. In addition, some marshy areas, distributaries in the coastal plains, are fairly clear and contain an astonishing number of fishes. They are found near and below the southern limits of the Sonoran Biotic Province in the State of Sonora. The few streams of the coastal plain and those of the western desert are also relatively clear and possess fishes. In the mountains and eastern desert the perennial rivers are silt-laden and extremely turbid, mainly because of irrigation practices. When these streams, such as the Rio Sonora, are impounded, the streams become clear below the dams, and the silt is deposited in the reservoirs. Some of the streams of the mountains, although beautiful to look at, are biological deserts because of the polluting effects of the numerous mine tailings found in the region. The Rio Nacozari, above and below the mining city of Nacozari, is an example. These waters were worked for almost two days without success. Although turbid streams are very productive, they yield relatively few species of fishes. The following is a numbered list of the collecting stations for reference convenience in the annotated list below.

1. A small tributary of the Rio Yaqui 21 miles south of Aqua Prieta, near the village of Cabullonas. According to natives this stream is normally a trickle, very turbid and averages (at this time of the year) from six to 12 inches in depth; water temperature 85° F. 14:VIII:1959.

2. Irrigation stream from an artesian well, ½ mile north of Calabasas. Water very clear with a gravel bottom; supports growths of *Potamogeton, Lemna, Nasturtium, Juncus* and *Salix*; water temperature 70° F. 15:VIII: 1959.

3. A small clear runoff stream 8 miles south of Calabasas; bottom of sand, gravel and small stones; no vegetation; water temperature 78° F. 15:VIII:1959.

4. Rio Sonora, 3 miles south of Baviacora; flood stage, water extremely turbid and roily; bottom of deep silt consisting of top soil, sand and small gravel; banks lined with *Salix*; water temperature 80° F. 17:VIII:1959.

5. A small artesian-well stream ½ mile north of Calabasas; banks very precipitous and heavily vegetated with *Salix*; aquatic plants consisting of *Potamogeton, Lemna* and alga; water temperature 75° F. 15:VIII: 1959.

6. A small creek 4 miles north of Tajos; water very clear; bottom mostly of small-sized gravel (mostly runoff); no vegetation; water temperature 85° F. 15:VIII:1959.

7. Rio Yaqui 6 miles north of Cuidad Obregon on highway 15; water moderately turbid; well-vegetated with *Eichornia, Polygonum, Jussieia, Cyperus, Juncus* and *Salix*; bottom of sand, gravel and mud; water temperature 80° F.; depth from 3 inches to 5 feet. 20: VIII:1959. This is in the coastal plain.

8. Marshy pools (distributaries of the Rio Yaqui) near highway 15, 33 miles north of Cuidad Obregon; slightly turbid, no current; bottom of mud and sand; heavily vegetated with a single species of *Sagittaria*; slightly brackish; water temperature 80° F. 20:VIII: 1959.

9. Rio Magdalena, one mile north of San Ignacio; water very turbid and rapidly flowing, 4 inches to 2 feet in depth; bottom of mud and/or sand and gravel; no vegetation; water temperature 80° F. 21:VIII:1959.

10. A small spring-fed stream, tributary to the Rio Magdalena, at Aqua Caliente; water very clear and cool; bottom of gravel and rocks; well vegetated with *Heteranthera, Nasturtium, Hydrocotle*, alga, *Salix* and shaded by poplars; water temperature 75° F. 21:VIII:1960.

Species List and Comments

Seventeen species, including three which are exotic to the fauna, were collected from the above stations. All measurements represent standard lengths (S.L.). With the exception of examples which were deposited with the Mexican Government at Mexico City and a few of each species sent to Dr. R. D. Suttkus, Tulane University, all of the fishes are deposited in the Oklahoma State University Museum of Zoology.

Dorosoma smithi Hubbs and Miller

This species, according to Alvarez (1950) is restricted to the Rio Piaxtla of Sinaloa, the state just south of Sonora, but in the original description Hubbs and Miller (1941) discussed three specimens from the Rio Muerto, a distributary of the Rio Yaqui, 45.5 road

miles south of Guaymas, Sonora. Our three specimens (54.0–57.5 mm. in S.L.) from station 7, then, are the first record of the species in the Yaqui proper. Hubbs and Miller (op. cit.) suggested that the Sonoran form might be a distinct subspecies, but the characters of our specimens are not particularly variable from those given for the type series. One specimen was deposited in Mexico City and one with Dr. Suttkus.

Catostomus insignis Baird and Girard

Twenty specimens of the Sonora sucker, ranging in size from 36.0 to 125.6 mm. in S.L., were taken at station 10. This is an additional locality record for this species, which was only reported from Mexico by Miller and Winn (1951). Some tiny specimens were noted, which indicates that spawning was in progress or completed.

Catostomus wigginsi Herre and Brock

The eight specimens taken at station 4 represent additional records for this little known sucker. The type locality for this species is in the west fork of the Rio San Miguel, 29 miles southeast of Magdalena, Sonora (Herre, 1936). Our specimens range from 40.0 to 68.0 mm. in S.L. and, since Herre and Brock did not include them in the original description the following may be of interest: Scales in the Lateral Line: 77–77–77–80–80–81–81–82; Dorsal Fin Rays: 8–8–9–9–9–9–9–10; and Anal Fin Rays: 7.

Arius liropus (Bristol)

Four specimens, ranging from 68.0 to 78.0 mm. in S.L., were secured from station 8. These fishes possess characters which fit those given by Regan (1906–1908) and may be a new record for the area.

Ictalurus melas (Rafinesque)

The black bullhead was reported as plentiful from northern Sonora by Miller and Winn (1951). We also found it, apparently the northern subspecies, to be extremely abundant in the Rio Yaqui (Station #7) in the coastal plains, only a short distance from the coast. Most of the specimens were discarded, two being retained for the sake of records (116.5–120.0 mm. in S.L.). *I. melas* was also found in some nearby irrigation ditches.

Agosia chrysogaster Girard

With the exception of *Poeciliopsis* this is the most widespread and abundant fish in Sonora. The following is a list, in the sequence of station—numbers taken—range of standard lengths, showing the distribution of our collections: 1 (43) 22.5–72.0 mm.; 2 (232) 22.0–52.0 mm.; 3 (5) 24.0–40.0 mm.; 4 (210) 22.5–64.5 mm.; 5 (19) 24.0–40.0 mm.; 6 (1) 35.5 mm.; 9 (399) 21.5–67.0 mm.; 10 (98) 15.4–63.2 mm. In the larger specimens from stations 1 and 9 some data were taken concerning the distribution of breeding tubercles. Since there is the possibility of a second species of *Agosia* in Sonora (Miller, 1958) these are included below. The anal fin tubercles are restricted to the lower three rays, on both sides; those of the pelvics to the dorsal side of the four outermost rays; those of the pectoral to the dorsal side of the outermost ray; and those of the dorsal fin are restricted to both sides of the first three rays. Tubercles were also noted on the cheeks and head but the tip of the snout is naked. The anal fin of the male is considerably larger than that of the female.

Gila purpurea (Girard)

This species, which characterizes the Rio Sonora and Rio Yaqui, was collected abundantly at station 1, 74 specimens ranging from 24.0 to 101.5 mm. in S.L.; and to a lesser extent at station 4, seven specimens from 31.0 to 72.3 mm. in length. At both collecting sites the large males possessed a bright red spot at the base of the pectoral, pelvic and anal fins.

Gila ditaenia Miller

Twenty specimens were taken from the strikingly clear water of the Rio Magdalena (station 9), 20.5 to 83.0 mm. in S.L. This is the *Gila* characteristic of the Magdalena drainage and, associated with the clear water and relatively dark bottom, are beautiful fishes when fresh. The general color is purplish with a bright chinese-red blotch at the bases of the pectoral, pelvic and anal fins (in the male).

Cyprinus carpio Linnaeus

Approximately 15 specimens were secured from the waters of station 7; only three of them were retained for records (111.0 to 125.5 mm. in S.L.). It is interesting to note that all of the specimens were of the mirror-carp variety. This is an additional locality record for the species in Mexico.

Campostoma ornatum Girard

Only a few specimens, eight (33.5 to 51.5 mm.) from station 4, 2 (44.0 to 47.4 mm.) from 6 and one (41.0 mm. in S.L.) from station 2, were found.

Poeciliopsis occidentalis (Baird and Girard)

The following are reported for the sake of records: 30 ♀ (26.0–40.5 mm.) (full of embryos) and 3 ♂ (20.5–29.5 mm.) station 1; one ♀ (21.0 mm.) and one ♂ (24.5 mm.) station 2; 29 ♀ (25.0–40.0 mm.) and one ♂ (21.0 mm.) station 4; 29 ♀ (26.5–40.5 mm.) and one ♂ (25.5 mm.) station 5; 38 ♀ (20.0–29.0 mm.) (larger ones with embryos) station 7; and 13 ♀ (13.0–26.5 mm.) and 2 ♂ (20.0 mm.) at station 9. The apparent disparity in the sex ratio can be explained by the fact that the mesh of our seine was unfortunately selective for the females.

Elops affinis Regan

Sixteen specimens were secured, 50.0 to 96.0 mm. in S.L., from station 8. However, several considerably larger ones were seen, but because of the intensely heavy growth of aquatic vegetation they were impossible to capture. The freshwater intrusion of this species, as well as that of *Arius* and *Mugil*, is probably not very far into the inland waters.

Mugil curema Valenciennes

The white mullet belongs primarily to a marine group that often enters fresh waters. Three specimens (53.0 to 70.5 mm.) from station 7 and one (69.0 mm.) from station 8 represent specmens from near the northern limits for this species.

Neomenis novemfasciatus (Gill)

A single specimen of this snapper, taken at station 7 and measuring 183.0 mm. in S.L., apparently represents a new record for the freshwaters of Sonora and still another addition to the relatively large secondary and tertiary-division fauna of the Rio Yaqui. The characters of the specimen match rather well those given by Jordan and Evermann (1900).

Lepomis macrochirus Rafinesque

Lepomis macrochirus purpurescens (Cope), the Georgia bluegill, was recorded for the first time in Mexico by Miller and Winn (1951) from San Bernardino Creek about one mile south of the border. The three specimens taken by us at station 7 are of the same subspecies and measured 33.0 to 61.5 mm. in S.L. This represents an additional locality record, which result, undoubtedly from escapes from nearby farmponds or irrigation ditches.

Natives informed us that three additional centrarchids have been planted in the area, although we did not obtain specimens of them. These are the largemouth bass, *Micropterus salmoides*, the green sunfish, *Lepomis cyanellus* and one of the crappies, *Pomoxis*.

Cichlasoma beani (Jordan)

The mojarra is the only cichlid which has been able to penetrate to the Rio Yaqui (Miller, 1958). Our eight specimens (44.0 to 144.0 mm.) were taken at station 7, which is very near the mouth of the river.

Dormitator latifrons (Richardson)

Two specimens of this sleeper, 92.5 and 132.0 mm. in S.L., were collected at station 8. It is thus obvious that this station and similar habitats, are occupied mainly by representatives of primarily marine families.

LITERATURE CITED

ALVAREZ, J. 1950. Claves para la determinacion de especes en los peces de las aguas continentales Mexicanos. *Sec. Mar., Dir. Gen. de Pesca e Ind. Con. Mexico, 143 p.*

HERRE, A. W. C. T. 1936. Notes on fishes in the Zoological Museum of Stanford University. IV. A new catostomid from Mexico and a new callionymid from Celebes and the Philippines. *Proc. Biol. Soc. Wash. 49:11–14.*

HUBBS, C. L. AND R. R. MILLER. 1941. *Dorosoma smithi*, the first known gizzard shad from the Pacific Drainage of Middle America. COPEIA. *1941:232–238.*

JORDAN, D. S. AND B. W. EVERMANN. 1900. The fishes of North and Middle America. IV. *U. S. Nat. Mus. Bull. 47.*

MILLER, R. R. 1958. Origin and affinities of the freshwater fish fauna of western North America. *In* Zoogeography, *Amer. Assoc. Adv. Sci. 51:187–222.*

MILLER, R. R. AND H. E. WINN. 1951. Additions to the known fish fauna of Mexico: three species and one subspecies from Sonora. *J. Wash. Acad. Sci. 41:83–84.*

REGAN, C. T. 1906–1908. Pisces. *Biologia Centrale-Americana. 8:xxxii + 203 p.*

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A Review of the Agamid Lizards of the Genus *Phoxophrys* Hubrecht

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THE agamid genus *Phoxophrys* Hubrecht closely resembles *Japalura* Gray (type species *variegata* Gray). The characters noted by Hubrecht (1881) to distinguish *Phoxophrys* were the absence of a dorsal crest and the presence of a few large, tubercular scales laterally. The enlarged scales of *Japalura* are simply unicarinate scales. To this diagnosis can be added that the supraciliary scales of *Phoxophrys* are juxtaposed or very slightly imbricate. In *Japalura* each supraciliary scale overlaps at least a third of its successor. The head of *Phoxophrys* is relatively short and deep, that of *Japalura* relatively long and flat. All species of *Japalura* seen have hair-like sense organs on the cephalic scales similar to those described and figured by Scortecci (1937, pl. 1) and Cherchi (1958) for species of *Agama*; this type of sense organ is absent in *Phoxophrys*. The rostral scale of *Japalura* is three or four times as wide as high and occupies the entire end of the snout; in *Phoxophrys* the rostral, if distinguishable at all, is at most twice as wide as high and occupies only the center of the end of the snout.

The tail of male *Phoxophrys* is markedly swollen basally, flattened above, and furnished with dorsolateral keels formed by enlarged, angular scales. In male *Japalura* the tail is compressed, oval in cross section, and not flattened above; usually a low mid-dorsal caudal crest is formed by a median row of enlarged keeled scales. Only *J. flaviceps* Barbour and Dunn deviates from this pattern. It foreshadows the extreme condition of *Phoxophrys* by having the tail flattened above proximally at the base and slightly swollen. The scales of the dorso-lateral row are carinate and larger than those of adjacent rows but not larger than the mid-dorsal ones, which are raised into a low crest. In the scalation of head and body, however, *flaviceps* does not differ from the other species of *Japalura*.

The lateral, superficial portion of the extra-columella of *Phoxophrys* (three of the five species examined) is narrow (length ca. 5 times width) and curved. In *Japalura* (*variegata, splendida, flaviceps, polygonata,* and *yunnanensis*) the extra-columella is wider (length ca. 3 to 4 times width) and straight. *Japalura swinhonis* has no extra-columella.

Females of *Phoxophrys* have non-swollen cylindrical tails that lack dorsolateral keels. Their heads (Fig. 1) illustrate the depth: length ratio better than those of males; the latter have large muscular swelling at the rear of the mandibles changing the apparent length but not the slope of the head.

Phoxophrys grahami Stejneger, the holotype (USNM 65500) of which was examined, agrees with *Japalura* in all of the diagnostic characters and must be placed in the latter genus.

In the course of this study the following specimens of *Japalura* were examined: *flaviceps*, 30; *grahami*, 1; *polygonata*, 14; *splendida*, 25; *swinhonis*, 20; *variegata*, 3; *yunnanensis*, 2. Specimens of *Phoxophrys* seen are listed under the appropriate species.

I am indebted to the following persons and institutions for permission to examine types and other material in their care: Mr. J. C. Battersby, British Museum (Natural History); Dr. M. Boeseman, Rijksmuseum van Natuurlijke Historie, Leiden; Dr. D. M. Cochran, United States National Museum; Dr. J. Guibé, Museum National d'Histoire Naturelle, Paris. The illustrations are the work of Miss Marion Pahl, Chicago Natural History Museum.

Abbreviations used are: CNHM (Chicago Natural History Museum) and USNM (United States National Museum).

Five species are known including one described below for the first time. They may be distinguished as follows:

1A A supraocular spine subequal to eye diameter .... *spiniceps* Smith.
B No supraocular spine; at most raised supraocular scales .... 2.
2A Nasal separated from supralabials; a low continuous vertebral crest at rear of body .... *nigrilabris* Peters.
B Nasal in contact with supralabials; no continuous vertebral crest at rear of body .... 3.
3A Supraciliary scales raised into a crest equal to half diameter of eye *tuberculata* Hubrecht.

B Supraciliary scales only slightly elevated . . . . 4.

4A Two continuous rows of infraorbitals; lateral scales of tail smooth *cephalum* Mocquard.

B One continuous row of infraorbitals; lateral scales of tail keeled *borneensis* new species.

Phoxophrys borneensis *sp. nov.*
(Figs. 1 and 2A)

Holotype.—USNM 130228 from Bundu Tuhan, Mount Kina Balu, North Borneo. Adult male collected at 4,500 feet on July 13, 1951 by D. H. Johnson.

Diagnosis.—No supraciliary spine; nasal in contact with supralabial; one continuous row of infraorbitals; gular scales sharply keeled, mucronate; nuchal crest with four thick (in males) or compressed (in females), conical scales; vertebral scale row posteriorly with widely separated, enlarged but not elevated scales. Males with eleven or twelve strongly keeled dorso-lateral scales on the tail near its base; scales on side of tail sharply keeled; four rows of keeled subcaudals near base.

Description of holotype.—Habitus slender, head large, limbs weak. Snout broadly rounded, steeply sloping, short; nostril in enlarged scale, opening laterally below canthal keel; nasal scale in contact with supralabials; head above relatively flat anterior to orbit, with weakly rugose scales; forehead with six keeled scales arranged in an inverted Y; supraorbital scales keeled, in about six rows, slightly smaller than circumorbitals; interorbital space concave, scales smaller than supraorbitals; canthal keel continued as raised supraciliary scales, latter scarcely imbricate; no azygous rostral scale, supralabials 12/13; two rows of infraorbitals, the lower consisting of smaller scales and interrupted below pupil; infralabials 12/13; mental shield larger than labials, followed by three enlarged scales in row below infralabials; a conspicuous swelling behind the jaw; gular scales smaller than postmentals, decreasing in size posteriorly, keeled, the keels directed posteriorly and medially.

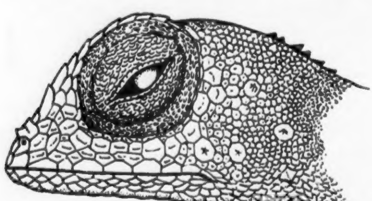

Fig. 1.—Head of female *Phoxophrys borneensis* (2 ×).

Tympanum hidden; temporal scales heterogeneous; a conspicuous conical nuchal scale on each side, a nuchal crest of four enlarged, thick scales, with smaller keeled scales intervening.

An oblique fold before the shoulder; an incomplete, transverse gular fold.

No dorsal crest; dorsal and lateral scales heterogeneous; dorsals weakly keeled; enlarged dorsals with raised keels; laterals smaller than dorsals, directed upwards and posteriorly, not keeled but usually with a raised apex; enlarged laterals tubercular, conical, and arranged in three oblique rows; ventrals larger than dorsals, uniform, strongly keeled.

Limbs with keeled scales, those in central bands around upper and lower arms and around thigh and calf distinctly larger; dorsal and lateral scales of digits keeled; infradigital lamellae of fourth finger 18, of fourth toe 22.

Base of tail distinctly swollen, flattened above, a truncated triangle in cross section; enlarged portion occupying basal third; rest of tail slender, cylindrical; scales of swollen base larger than rest, those of top and sides weakly keeled, 11 or 12 scales along dorsolateral keel enlarged, angular, and spinous, four rows along ventral edge enlarged and strongly keeled; scales of posterior two thirds of tail strongly keeled; a ring of small scales separates specialized scales from anus and legs.

Color (in alcohol) grayish black; two bluish white interorbital stripes; upper lip whitish; conical nuchal scales and nuchal crest bluish white; three oblique pale bluish bands on sides crossing back, corresponding to position of enlarged lateral scales; throat and chin whitish, marked with a network of black lines; belly bluish spotted with black; limbs dark above, light below; swollen part of tail yellowish white marked with black above; slender part of tail banded with black and blue.

Total length 155 mm.; tail length 92, width 9.5; head length 22.

Paratypes.—CNHM 71856, a male from the type locality, collected on August 1, 1951. It differs from the above only in having a small azygous rostral, 11 supralabials, 11/12 infralabials and somewhat duller coloration. The infradigital lamellae are 18 on the fourth finger and 23 on the fourth toe.

Total length 170 mm.; tail length 104, width 8.5; head 24.5.

CNHM 67326, an adult female from the Trusan River area, Fifth Division, Sarawak. It lacks the swellings behind the jaws and at the base of the tail. The nuchal crest consists of nine successive, raised scales and, thus, does not have the jagged appearance of the nuchal crest in the males. The rostral is small and azygous. There are 11 upper and 11 lower labials. The infradigital scales are 18 on the fourth finger and 19 on the fourth toe. The color is a faded brown, but the same narrow, light, oblique bands are present on the body. The body contains two large eggs.

Total length 151 mm.; tail length 90 mm.; head 17 mm.

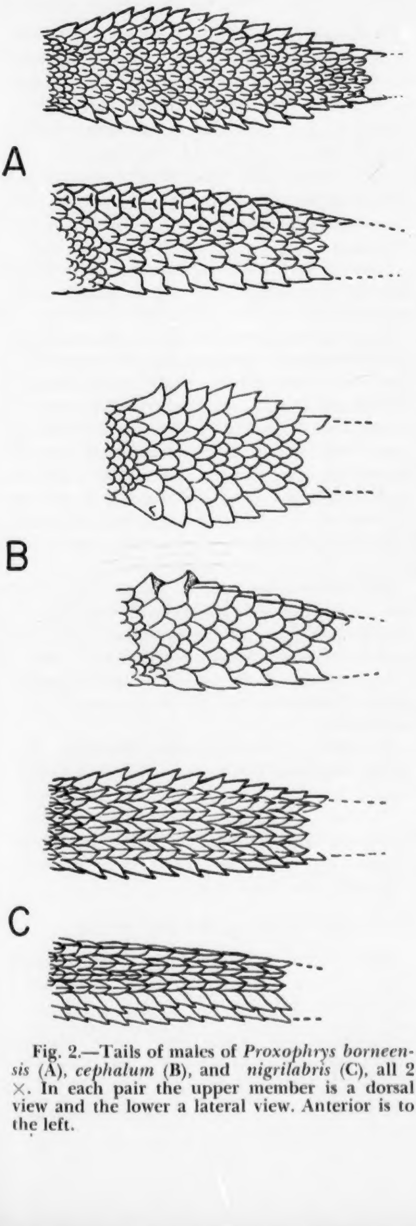

Fig. 2.—Tails of males of *Proxophrys borneensis* (A), *cephalum* (B), and *nigrilabris* (C), all 2 ×. In each pair the upper member is a dorsal view and the lower a lateral view. Anterior is to the left.

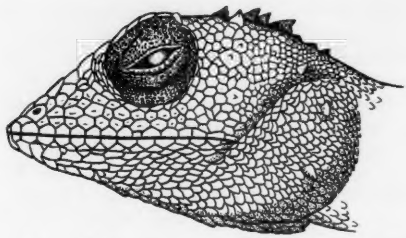

Fig. 3.—Head of male *Phoxophrys cephalum* (2 ×).

Remarks.—Though in general resembling *cephalum* and occurring with it at least on Mount Kina Balu, *borneensis* differs from *cephalum* in the following characters: number of continuous infraorbital scale rows (Figs. 1 and 3); carination of the gular scales and of the lateral caudal scales (Fig. 2); number of rows of subcaudals; and number of enlarged scales on dorsolateral border of tail. These differences are brought out by comparison of the two diagnoses.

The supraciliary scales of *borneensis* are lower than those of *tuberculata* and *spiniceps*. The latter also differs from *borneensis*, in coloration, having no light bands on the body, and in the weaker carination of the gular scales. *Phoxophrys nigrilabris* has more spinose gular scales than *borneensis* and further differs from the latter in the characters noted in the key (see above).

Localities.—North Borneo: Jesselton District, Mount Kina Balu, Bundu Tuhan, 4,500 feet. Sarawak: Fifth Division, Trusan River.

Phoxophrys cephalum (Mocquard)

(Figs. 2B and 3)

Pelturagonia cephalum Mocquard, 1890, Nouv. Arch. Mus. Hist. Nat., (3), 2:130, pl. 7, figs. 4-4a—Kina Balu.

Japalura nigrilabris (non Peters) de Rooij, 1915, Reptiles Indo-Austr. Arch., 1:93.

Taxonomic notes.—Although Boulenger (1891) and Mocquard (1892) agreed that *cephalum* and *nigrilabris* Peters were iden-

tical, the two are readily distinguished. For one thing, *nigrilabris* has a low but distinct dorsal crest on the posterior third of the back in the two at hand and in Boulenger's Matang specimen, whereas *cephalum* has at most a few enlarged vertebral scales separated from one another. Also, the underside of the tail in *cephalum* has only two rows of enlarged scales near the base (at least in males), whereas *nigrilabris* has four enlarged rows near the base and two rows distally. The scales on the side of the tail are smooth or very feebly keeled in *cephalum* but strongly keeled in *nigrilabris*. In general *nigrilabris* is more spinose than *cephalum*, a difference especially marked on the throat.

De Rooij's description of *nigrilabris* is based entirely on the type series of *cephalum*, which she had examined.

Diagnosis.—No supraciliary spines; nasal in contact with supralabials; two continuous rows of infraorbitals; gular scales obtusely keeled or smooth; a short nuchal crest of seven or eight thick, conical scales; vertebral scale row posteriorly with a few feebly elevated, widely separated enlarged scales. Males with six or seven strongly keeled dorso-lateral scales on tail near its base; scales on side of tail smooth; two rows of enlarged, keeled subcaudals.

Material.—Four males (including two syntypes), snout-vent 71–84 mm.; tail (in one) 0.64 of total length. Six females (including three syntypes), 59–74 mm., largest with mature ova; tail 0.57–0.62 of total length. Supralabials 14 (1), 13/14 (1), 12 (2), 11 (1); infralabials 14 (1), 12/13 (2), 11 (1), 10 (1); infradigital scales of fourth finger 18 (1), 19 (1), 20 (2), 21 (1); of fourth toe 25 (1), 26 (3), 26/27 (1).

In one syntype, the nasal is narrowly separated from the supralabials on the right side of the head. A second syntype has only one continuous row of infraorbitals. All agree in the other characters of the diagnosis.

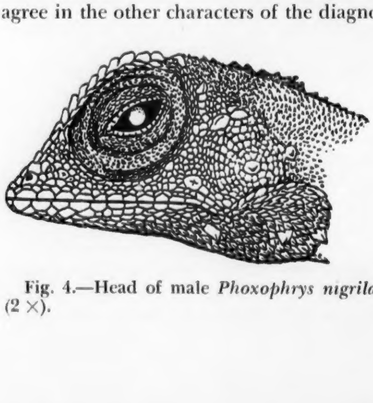

Fig. 4.—Head of male *Phoxophrys nigrilabris* (2 ×).

Localities.—North Borneo: Jesselton District, Mount Kina Balu, Bundu Tuhan (4,500 feet), Ranau. "Borneo".

Phoxophrys nigrilabris (Peters)
(Figs. 2C and 4)

Otocryptis (*Japalura*) *nigrilabris* Peters, 1864, Monatsber. Akad. Wiss. Berlin, **1864**:385—Pulo Matjan, Indonesian Borneo.

Taxonomic notes.—The two Sarawak males referred to below (*material*) are identical with the specimen Boulenger (1885) had before him. According to Dr. Heinz Wermuth of the Zoologische Museum, Berlin, Peters' sole example of *nigrilabris* is no longer extant and, since Peters' description was exceedingly brief, we must rely on Boulenger's description and material for a definition.

Comparison with *cephalum*, with which *nigrilabris* has been confused, has been made above.

Diagnosis.—No supraciliary spine; nasal separated from supralabials; two continuous rows of infraorbitals; gular scales sharply keeled, spinose; a nuchal crest of six to twelve compressed scales; vertebral scale row posteriorly with a continuous series of enlarged, elevated scales. Males with eight or nine strongly keeled dorsolateral scales on tail near its base; scales on side of tail keeled; four rows of enlarged keeled subcaudals near base.

Material.—Two males; snout-vent 52–54 mm., tail (in one) 0.61 of total; supralabials 12; infralabials 12; infradigital scales of fourth finger 16, 18; of fourth toe 21, 23.

Six additional specimens in Sarawak Museum examined only for purposes of identifications.

Localities.—Sarawak: First Division, Kuching, Matang, Santubong, Tambak. Indonesian Borneo: Pulo Matjan (Peters, 1864).

De Rooij (1915, p. 94) lists other Bornean localities, but they cannot be included here because she did not distinguish between *cephalum* and *nigrilabris*.

Phoxophrys spiniceps (Smith)

Phoxophrys spiniceps Smith, 1925, Jour. Sarawak Mus., **3**: 7, pl. 1, fig. 1—Mount Murud, Sarawak.

Diagnosis.—A supraciliary spine formed by a scale about three-fourths eye diameter; nasal in contact with second supralabial; one continuous row of infraorbitals; gular scales

keeled; a nuchal crest of three spinose scales separated by two to six small, keeled scales; vertebral scale row posteriorly with widely separated enlarged scales. Male unknown, but female (and, therefore, probably male) with keeled scales on side of tail; two rows of enlarged, keeled subcaudals.

Material.—Holotype, adult female with one large egg; snout-vent 60.3 mm.; supralabials 11, infralabials 12.

Locality.—Sarawak: Fifth Division, Mount Murud.

Phoxophrys tuberculata (Hubrecht)

Phoxophrys tuberculata Hubrecht, 1881, Notes Leyden Mus., 3:51—Batang Singalang, Sumatra.

Japalura robinsoni Boulenger, 1920, Jour. Fed. Malay States Mus., 8:287, pl. 8, fig. 1—Sungei Kumbang, Korintji Peak, Sumatra.

Taxonomic notes.—After examination of the types, I conclude that *robinsoni* is a synonym of *tuberculata.* Both have sharply raised supraciliaries forming a supraorbital crest, several strongly compressed supraoculars, one row of large and one of small infraorbitals, tubercular temporals, and no dorsal or nuchal crest. The type localities are in the mountainous country near Padang, Sumatra, and are separated by about 250 kilometers.

Contrary to de Rooij's figure (1915, fig. 48), the type of *tuberculata* does not have a dorsal crest.

Diagnosis.—No supraciliary spine, but supraciliary scales raised into crest; nasal in contact with first two supralabials; two continuous rows of infraorbitals; gular scales sharply keeled; no nuchal crest; vertebral scale row posteriorly without a continuous series of enlarged scales. Male unknown, but females (and, therefore, probably male also) with keeled scales on sides of tail.

Material.—Two females (types of *tuberculata* and *robinsoni*): snout-vent 35–43 mm.; supralabials 12, infralabials 8, 9; infradigital scales on fourth toe 19.

Localities.—Western Sumatra: Batang Singalang, Mount Korintji.

Literature Cited

Boulenger, G. A. 1885. *Catalogue of the lizards in the British Museum (Natural History). 2nd ed., 1:XII+436, 32 pls.*

———. 1891. Remarks on the herpetological fauna of Mount Kina Baloo, North Borneo. *Ann. Mag. Nat. Hist. Ser. 6, 7:341–345.*

Cherchi, M. A. 1958. Note su *Agama robecchii* Blgr. *Atti. Soc. Ital. Sci. Nat. 97:233–238, pls. 9–11.*

Hubrecht, A. A. W. 1881. On a new genus and species of Agamidae from Sumatra. *Notes Leyden Mus. 3:51–52.*

Mocquard, M. F. 1890. Recherches sur la fauna herpétologique des Iles de Bornéo et de Palawan. *Nouv. Arch. Mus. Hist. Nat., Ser. 3, 2: 15–168, pls. 7–11.*

———. 1892. Nouvelle contribution a la faune herpétologique de Bornéo. *Mem. Soc. Zool. France. 5:190–206, pl. 7.*

Peters, Wilhelm. 1864. Über einige neue Säugethiere, Amphibien, und Fische. *Monatsber. Akad. Wiss. Berlin. 1864:381–399.*

de Rooij, Nelly. 1915. *The reptiles of the Indo-Australian Archipelago. 1:XIV+384, 132 text figs.*

Scortecci, Giuseppe. 1937. Gli organi di senso della pelle degli Agamidi. *Mem. Soc. Ital. Sci. Nat. 10:159–206, 2 pls.*

Smith, M. A. 1925. On a collection of reptiles and amphibians from Mt. Murud, Borneo. *Sarawak Mus. Jour. 3:5–14, pl. 1.*

Chicago Natural History Museum,
Chicago, Illinois

Two New Genera of African Bufonids, with Remarks on the Phylogeny of Related Genera

J. A. Tihen

In the course of a study of the comparative osteology of *Bufo* and related genera, three African forms have been found to exhibit characteristics that preclude their inclusion in any of the currently recognized genera of the Bufonidae. These will first be characterized briefly; a more complete description and evaluation of the features they exhibit is incorporated in the subsequent general discussion.

In addition to Drs. Raymond Laurent and Robert Mertens, whose aid is further acknowledged subsequently, I would like to express my appreciation to the following in-

stitutions and individuals who generously provided specimens for this study: Drs. C. M. Bogert and R. G. Zweifel of the American Museum of Natural History, Donald Hoffmeister and H. M. Smith of the University of Illinois, R. F. Inger and Hymen Marx of the Chicago Natural History Museum, Max Poll of the Musée Royale du Congo Belge, and Ernest Williams of the Harvard Museum of Comparative Zoology.

Laurentophryne, gen. nov.

Type species.—*Wolterstorffina parkeri* Laurent, 1950, *Rev. Zool. Bot. Afr.*, 44(1):3.

Referred forms.—Known from the type species only.

Diagnosis.—An African bufonid related to *Nectophryne* but differing in absence of lamelliform subdigital pads and in possession of a palatine bone; differing from *Wolterstorffina, Bufo* and *Nectophrynoides* in possessing only seven presacral vertebrae and in having the palatine reduced in extent, and from the last two genera also in the fusion of the sacrum and coccyx.

Mertensophryne, gen. nov.

Type species.—*Bufo* (*micranotis*) *rondoensis* Loveridge, 1942, *Bull. Mus. Comp. Zoology*, 91:387.

Referred forms.—*Bufo ushoranus* Loveridge; it is assumed that *Bufo micranotis micranotis* Loveridge is also referable to this genus, but this assumption has not been verified by examination of any specimens.

Diagnosis.—An African bufonid resembling *Nectophryne* and *Laurentophryne* in the reduction of number of presacral vertebrae to seven and in the absence of an adductor longus; differing in having the sacrum and coccyx separate, in possession of extensively developed quadratojugals and palatines, and in other details described below.

The two new genera are named in honor of Dr. Raymond Laurent of the University of Elizabethville and Dr. Robert Mertens of the Senckenbergische Naturforschende Gesellschaft, respectively, in recognition of their extensive contributions to knowledge of African amphibians and their generous provision of specimens, information, and ideas for my use.

Discussion

Each of the above genera is at present known only from the species referred to above. I have, however, seen a limited number of the small African forms now included in *Bufo*; some of the forms not seen may prove referable to *Mertensophryne*. Species or subspecies that have been examined and retained in the genus *Bufo* include: *fenoulheti obtusum, lonnbergi nairobiensis, melanopleura, parkeri, taitanus nyikae, vertebralis* and *vittatus.*

Comments on the osteology of genera other than *Bufo* are based primarily on the following specimens: *Ansonia muelleri*, CNHM 50862 and 96103, alizarin preparations; *Ansonia* sp., CNHM 77415 and 77422, alizarin preparations (these represent two undescribed species; a revision of this genus by Dr. Inger is in press, and to avoid any possibility of premature publication of his manuscript names, these will be referred to only as "form L" and "form M" respectively); *Laurentophryne parkeri*, MRCB four specimens, three alizarin preparations and one dry skeleton; *Mertensophryne m. rondoensis*, MCZ 25095-96, alizarin preparations; *Nectophryne afra*, CNHM 3576, limited dissection and radiograph; *Nectophrynoides vivipara*, CNHM 21045 and MCZ 1254, dried skeletons; *Pedostibes hosi*, MCZ 9456, CNHM 77391, UI 25363, two dried skeletons and one limited dissection; *Pelophryne albotaeniata*, CNHM 51371, alizarin preparation; *Pseudobufo subasper*, MCZ 19579, dried skeleton; *Wolterstorffina parvipalmata*, SMF 28871-72, alizarin preparations. Musculature and other features of the soft anatomy of all specimens were examined prior to and in the course of skeletal preparation.

Thigh musculature was examined in several other specimens and forms in the collections of the Chicago Natural History Museum. These include *Pseudobufo subasper*, *Pedostibes rugosus* and several forms of *Ansonia*, including currently unnamed forms now in the process of description by Dr. Inger, as well as examples of the various species now recognized.

The following discussion involves primarily only the fully arciferal genera of the family Bufonidae. This is admittedly a somewhat arbitrary limitation, since the arciferal genera are perhaps less closely related inter se than certain ones are to arcifero-firmisternal genera. The limitation is perhaps defensible on the basis of my knowledge that various colleagues are attacking the problems involved in the relationships of the fully or partially firmisternal genera to each other and to arciferal forms.

The entire bufonid-atelopodid complex

has been defined and clearly delimited by Griffiths (1959); according to this definition it would include, with the two genera here proposed, sixteen extant genera. If the poorly known *Werneria* is properly referable to this complex there are seventeen genera, but because of the very limited amount of information available concerning that genus and the consequent uncertainty of proper family reference, I choose to disregard it completely for the present. Of these sixteen genera six are arcifero-firmisternal or firmisternal in the classical sense of the terms, if not in the sense that these terms have been redefined by Griffiths. These six genera, excluded from the present discussion, are: *Atelopus, Brachycephalus, Cacophryne, Dendrophryniscus, Didynamipus* and *Oreophrynella*. The remaining ten genera are: *Ansonia, Bufo, Laurentophryne, Mertensophryne, Nectophryne, Nectophrynoides, Pedostibes, Pelophryne, Pseudobufo* and *Wolterstorffina*. The great majority of species included in this assemblage belong to the genus *Bufo* itself. This genus is osteologically diverse in a number of respects, but we will not be concerned with an analysis of the variation within the genus. Some aspects of this variation will be mentioned, insofar as they bear on the apparent origin of other genera. The features listed as characteristic for the genus are those that have appeared constant among approximately sixty species that I have examined, including every clearly recognizable major group within the genus, and including forms from every major geographic area in which the genus occurs.

The genus *Nectophrynoides* is unique among bufonids in the possession of an omosternum, suggesting that all forms in the direct line of ancestry of the genus must also have possessed an omosternum, and thus that the line leading to *Nectophrynoides* diverged from the remainder of the bufonid stock quite early in the history of the group. If this is true, then such specializations as exist in both *Nectophrynoides* and in several other genera must be the result of independent development in two different lines. This requires the assumption of a rather extensive amount of parallel development, but such an assumption is more acceptable than any of those relating this genus more closely to any of the other extant bufonid genera.

This genus is also of course unique in its ovoviviparous mode of reproduction.

The genus *Nectophryne* is unique in the possession of distinctive lamelliform subdigital pads. This peculiar specialization provides no clue to the ancestry of the genus.

Pseudobufo is distinctive in exhibiting a very limited degree of ossification of the cartilaginous elements of the skeleton. The sphenethmoid is completely unossified, the otic and occipital elements only weakly ossified. The intervertebral bodies remain cartilaginous. They tend to adhere to the preceding vertebrae, so that the vertebral column is actually procoelous, but if only the bony vertebral column were available this would be considered an amphicoelous form. The ends of the long bones, the ends of the vertebral diapophyses and of the metacarpals and metatarsals all remain largely catilaginous. This limited ossification is certainly not indicative of a primitive position for the genus, but is probably best considered one expression of a limited degree of neoteny, associated in turn with the aquatic mode of life.

Bufo is the only member of the family in which a distinct and clearly recognizable adductor longus muscle is present in the thigh. This muscle varies slightly in extent from group to group within the genus, but is always clearly present and at least moderately extensive. Noble (1922) has expressed the belief that primitive anurans lacked such a muscle, and that it has appeared independently in several different lines of anuran evolution. Muscle slips could, of course, be separated from an undifferentiated mass in any line having a functional need for such change. But that this would occur in exactly the same manner in groups of such diverse habits as discoglossids, pelobatids and bufonids seems unlikely. Loss of a muscle, on the other hand, can be accomplished by a number of different processes, each of which produces the same apparent end result. It is much more likely that the adductor longus was present in early salientians and that it has been lost in a limited number of forms rather than that it has developed independently several times. If this hypothesis is correct, then in this particular respect the genus *Bufo* exhibits a more primitive condition than any of the other bufonid genera.

None of the remaining genera to be considered exhibit any completely unique characteristics; rather they are characterized by particular combinations of features. I am here concerned primarily with osteological features, but attention is also called to certain myological and reproductive characteristics.

In *Bufo*, as in most anurans, the tensor fasciae latae is a rather short muscle, originating from the ilium well posterior to the sacrum and inserting on the surface of the cruralis-gluteus complex. The same condition obtains in all specimens of *Nectophrynoides* and *Pedostibes* seen. In all other genera, excepting *Ansonia* and *Mertensophryne*, this muscle consistently originates from, or very near, the level of the sacrum; it is thus a very long, strap-like muscle. The muscle is similarly elongate in most specimens of most species of *Ansonia*, though occasional individuals exhibit a somewhat intermediate condition; in *Ansonia* "form M" it has the same relationships as in *Bufo*. For one specimen of *Mertensophryne rondoensis* my notes indicate that the tensor fasciae latae was "very long, extending nearly to the anterior end of the ilium." This notation was made prior to my recognition of the taxonomic significance of this feature; subsequent skeletonization of the specimen made it impossible to recheck the accuracy of the observation, but I can see no reason to seriously question its accuracy. Nevertheless, a second specimen of this same form and three specimens of *M. ushoranus* possessed a short muscle, fully comparable in extent to that of *Bufo*.

Neither the taxonomic nor functional significance of the elongate tensor fasciae latae can be explored fully at the present time. The elongate condition also occurs in *Cacophryne* and apparently in *Atelopus* (*vide* Noble op. cit.), but *Dendrophryniscus stelzneri* resembles *Bufo* in this respect.

Life history data are not available for all of the genera treated, but such data as are available correlate closely with the morphological variations. *Nectophrynoides* is unique and undoubtedly highly specialized in being ovoviviparous, with direct development. *Bufo* typically produces small pigmented eggs, usually laid in strings. The complete clutch numbers from six or seven hundred in *Bufo quercicus* to several thousand in many of the larger species (cf. Inger, 1954). The recently described *B. melanopleura* constitutes a marked exception to this generalization. Schmidt and Inger (1959) state: "Despite the small size of the adult mature females [20–25 mm. snout-vent length], the eggs of *melanopleura* are large, measuring 1.8 to 2.0 mm. in diameter. This size corresponds to some of the largest *Bufo* eggs, which belong to much larger toads . . . The egg count of *melanopleura* is very small. One female (22.2 mm.) held 17 large ova with pigmented animal hemispheres in the right ovary and 14 in the left. A second female (22.7 mm) contained 19 and 16 mature ova in the right and left ovaries respectively. Each ovary had as many small, immature ova as mature ones." Egg size and number in this species are thus quite comparable to those of certain other genera, as will be seen, but in all other features considered it resembles the other small earless African toads retained in *Bufo*.

In *Pedostibes* the number and size of the eggs and their manner of deposition are apparently identical with these same features in *Bufo* (Roux, 1906). Schmidt and Inger also offer the following information on *Mertensophryne ushoranus*: "The ova of *ushoranus* . . . are only 1.0 mm in diameter and much smaller than those of *melanopleura*. However, the ova are unusual in that they lack pigment. The right ovary of one female contained 110 enlarged ova, that of a second female 234." This genus would appear to differ from *Bufo* in having unpigmented eggs, and in having a somewhat lesser total complement than any known *Bufo* excepting *melanopleura*. In *Ansonia* the eggs are large, averaging slightly over 2 mm. in diameter, unpigmented, and number somewhat under 200 per clutch (Inger, 1954). I do not know the situation in *Wolterstorffina* or *Pseudobufo*, but in *Pelophryne* (Inger, ibid.), *Nectophryne* (Boulenger, 1913) and *Laurentophryne* the eggs are similarly large and unpigmented; a complete clutch, however, numbers only approximately thirty eggs.

To summarize, *Bufo* (excepting *melanopleura*) and *Pedostibes* are in close agreement and exhibit a presumably primitive condition, with many small pigmented eggs. In all other genera for which information is available the eggs are unpigmented. The number is somewhat reduced in *Mertensophryne*, further reduced with a definite increase in size in *Ansonia*, and very markedly reduced in the remaining genera, with *Nectophrynoides* occupying a unique position. These facts correlate well with the hypothetical phylogney of the group (Fig. 1).

The condition of the vertebral column in *Bufo* is also presumably unspecialized, and is shared with several of the other genera. There are eight presacral vertebrae and the coccyx articulates with the sacrum by a double condyle. Exactly the same situation is found in *Pedostibes* and *Ansonia*; *Pseudobufo* can be considered identical except for

the failure of the intervertebral bodies to ossify. *Nectophrynoides* is also identical except for the fact that the sacral condyle is essentially single, with only a trace of a former (or incipient?) double nature. In *Wolterstorffina* there are eight presacral vertebrae, but the sacrum and coccyx are fused. The remaining genera have only seven presacral vertebrae. These facts also will fit the hypothetical phylogeny here proposed (Fig. 1).

The reduction in number of vertebrae is not the result of obvious fusion between any two of the original eight; it is thought rather to result from a forward shift of the sacral articulation, with the original sacral vertebra perhaps becoming incorporated into the coccyx. The condition found in *Mertensophryne* suggests such a process. In that genus there are seven presacral vertebra; the eighth, or sacral, vertebra articulates with the coccyx by a single condyle—just the same sort of articulation as that between the sacral and the next anterior vertebrae in forms with a complete vertebral complement. The anterior end of the coccyx exhibits a very obvious vertebral structure; prezygapophyses are still present, articulating with postzygapophyses on the sacral vertebra. In the other three genera, *Nectophryne, Laurentophryne* and *Pelophryne* the (new) sacrum and coccyx are fused. In these also there is usually some indication of vertebral structure at the anterior end of the coccyx, at least to the extent of possessing exceptionally large postsacral nerve foramina. In *Pelophryne* the cervical and the first post-cervical vertebrae are fused, so that there are actually only six independent presarcal vertebrae; this is, however, an obvious fusion, and not fully comparable to the reduction from eight to seven described above. Again, a resemblance to certain firmisternal forms can be noted.

In *Pedostibes*, some groups of *Bufo*, and *Pseudobufo* the frontoparietal is separate from the prootic; in all other genera the bones are fused. This fusion is thought to have occurred independently in *Nectophrynoides*, but the other genera are believed to have been derived from a section of *Bufo* in which the fusion had already occurred. *Pedostibes*, on the other hand, is presumably derived from a section of *Bufo* that retained these two bones as separate elements. In general one does not like to postulate that two elements, once fused, will later separate, but in the case of *Pseudobufo* such an apparent separation is readily explicable; ossification of the prootic simply does not proceed to the point of ankylosis with the frontoparietal.

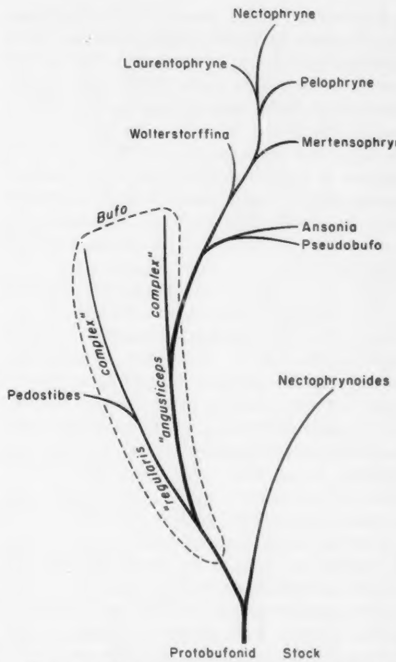

Fig. 1.—Diagrammatic representation of the suggested relationships among the fully arciferal bufonid genera.

At this point a brief recapitulation of the characters so far considered and a brief discussion of certain aspects of variation within the genus *Bufo* may help to clarify the discussion to follow. We have already postulated that *Nectophrynoides* is the present representative of a line that branched from the remainder of the bufonid stock at a very early date. This line is thus not involved in the development of the remaining genera. Among the remaining genera, every characteristic considered is represented in its presumably most primitive condition in the genus *Bufo*. This primitive condition may be shared with one or more of the other genera or in a few instances be modified in certain forms within the genus. *Bufo* is defined, then, not on the basis of any modifications that have appeared within the genus, but rather on the retention of a certain set of primitive features.

Retention of this particular set of primitive features does not imply retention of a primitive condition of all other features in every evolutionary line within the genus. Two main lines were probably established quite early in the history of the genus, even though a few more or less intermediate forms are still in existence. To retain the reference species within the geographic area primarily involved, I will refer to these two main lines as the *regularis* complex and the *angusticeps* complex.

Both lines are in agreement with respect to the characteristics so far considered, excepting for the frontoparietal prootic relationship. Fusion of these two elements is universal in the *angusticeps* complex; it also occurs in one, perhaps two, groups within the *regularis* complex, but these groups are dissimilar to any member of the *angusticeps* complex in so many other respects that it must be interpreted as an independent and secondary occurrence within that line.

It seems likely that within any given line of descent, as well as in the overall broad picture of amphibian evolution, the tendency is for a reduction in the extent and thickness of the dermal skull elements. There is no obvious reason to believe that the reverse is true in *Bufo* or the Bufonidae. Even disregarding dermal coossification, we find more extensive, more closely conjoined, and heavier skull elements in portions of the *regularis* complex than among any of the other genera or groups here involved. This condition is most frequently associated with at least moderately extensive dermal coossification and ornamentation. While it is certainly true that the extremes of ornamentation and dermal ossification (e.g., *empusus*, *typhonius*) cannot be considered primitive, the earliest bufonids probably exhibited a rather complete ossification of the skull and at least moderately extensive involvement of the dermis. Perhaps the condition was not too dissimilar to that found in such forms as *regularis*, *funereus*, *mauritanicus*, and so on.

Dermal ornamentation is completely lacking in the *angusticeps* complex. Presumably correlated with this is the fact that the occipital artery passes along a groove that is open dorsally. A very few members of the *regularis* complex have similarly reduced ornamentation, but in the great majority the ornamentation is relatively extensive and the occipital artery passes through a bony canal, covered with bone dorsally, rather than an open groove. Some reduction in the extent of ossification of a number of elements occurs in both the *regularis* and the *angusticeps* complex, but is far more prominent and frequent in the latter. Certain species in this complex, such as *calamita* and *raddei*, have even developed an extensive frontoparietal fontanelle. In all members of this group the otic plate of the squamosal is reduced to the point of virtual or complete absence. In several members the quadratojugal and the pterygoid are at least slightly reduced as compared with the usual condition in the *regularis* complex, but in none is the quadratojugal reduced to the point where it fails to make contact with the maxilla, nor is the medial arm of the pterygoid reduced to the point of obsolescence as it is in some of the other genera.

With respect to the above features, all of which may be summarized as reflecting the extent of ossification of dermal contributions to the cranium, *Pedostibes* is comparable to typical members of the *regularis* complex. It differs from them in the absence of the adductor longus, already mentioned, and in the expansion of the tips of the terminal phalanges, but not in any of the other features considered. It seems derivable from the *regularis* complex of *Bufo*; the only suggestion of relationship to the remaining genera discussed is the loss of the adductor longus and the presence of expanded phalangeal tips. This latter feature characterizes all bufonid genera excepting *Bufo* and *Mertensophryne*, though poorly expressed in *Pseudobufo* as a result of the weak ossification. Because of the many dissimilarities between *Pedostibes* and the remaining genera, this characteristic must have developed independently in the two lines.

The remaining genera, *Ansonia*, *Laurentophryne*, *Mertensophryne*, *Nectophryne*, *Pelophryne*, *Pseudobufo* and *Wolterstorffina*, are probably members of a single line, as indicated by the peculiar development of the tensor fasciae latae, already discussed, in at least some members of each. This line seems to have derived from the *angusticeps* complex of *Bufo*, which includes such forms as the small, earless *B. taitanus* and related species. The fusion of the frontoparietal with the prootic and the reduced dermal ossification characterizing that complex are continued, and in some instances exaggerated, in the various derivatives of this line. Loss or reduction of the auditory apparatus, found in certain members of the *angusticeps*

complex, also occurs in certain of these genera.

Of these other genera, *Ansonia* is the most similar to *Bufo* in some respects, *Mertensophryne* in others. In neither *Ansonia* nor *Mertensophryne* is the elongation of the tensor fasciae latae universal; in the latter it may not even normally occur. *Mertensophryne* retains the general cranial characteristics of certain *Bufo*, the unexpanded terminal phalanges, and apparently an egg size and number more nearly comparable to *Bufo* than to that of other genera. *Ansonia* on the other hand shows a reduction of various cranial elements (though retaining the columella) and a greater departure from the *Bufo* type of egg than *Mertensophryne*, but has retained an essentially unmodified vertebral column. Special larval features have been described by Inger (op. cit.).

Pseudobufo is very similar to *Ansonia* in many features, although markedly different in superficial appearance. The differences that do exist are mostly simple reflections of size and of the extent of ossification of the cartilaginous skeletal elements. These two genera also possess in common a prominent transverse ridge on the ventral surface of the alate portion of the parasphenoid as another feature indicative of a close relationship.

Five genera have all undergone some modification of the vertebral column. In *Wolterstorffina* this modification consists only of the fusion of the sacrum with the coccyx. In that genus, as in *Ansonia*, the quadratojugal is reduced to the point of virtual extinction; the medial arm of the pterygoid, though not extensive, is not so markedly reduced as in *Ansonia*. The tympanum and columella have been lost.

Mertensophryne carries the vertebral modification one step further with the reduction of the number of presacral vertebrae to seven; the presumably new sacral vertebra is not yet fused with the reconstituted coccyx, and the anterior end of the coccyx exhibits an obvious vertebral structure, interpreted as a vestige of the original sacrum. But this genus has, as mentioned above, retained several relatively unspecialized features, including an extensive quadratojugal and a reasonably extensive medial arm of the pterygoid. Columella and tympanum are lost.

The remaining three genera, *Laurentophryne*, *Nectophryne* and *Pelophryne* share the next step in the modification of the vertebral column—a reduced number of presacral vertebrae plus a fusion of the sacrum with the coccyx. They resemble each other also in the greatly reduced number of eggs, in the extreme reduction of the quadratojugal and the medial arm of the pterygoid, and a reduction in extent of the palatine bone. This element is present in *Laurentophryne*, but is represented only by a thin sliver that is not in contact with either the sphenethmoid or the maxilla; in the other two genera it appears to be entirely lacking (fide Ramaswami, 1936, for *Nectophryne*). The tympanum and columella are lost in *Laurentophryne* and *Nectophryne*, but retained in some, if not all, species of *Pelophryne*.

The characteristics of the various genera are summarized in Table I.

If we accept the postulates concerning the direction of evolution of the various features mentioned, then the nearest common ancestor of all of these genera must have had the following characteristics: Omosternum present; adductor longus present; tensor fasciae latae of normal extent; eight presacral vertebrae; sacrum articulating with the coccyx, probably by a double condyle; frontoparietal and prootic independent; at least moderate involvement of the derm in the ossification of the cranium; columella, palatine, quadratojugal and pterygoid all present and of normal extent; eggs numerous, small, pigmented.

From such a hypothetical ancestor *Nectophrynoides* would be derived at an early date; subsequent specializations within the line leading to this genus in part parallel those occurring within certain portions of the main stock. After this divergence, the main stock lost the omosternum; this is the only change essential to production of a form basically identical with the more primitive members of the *regularis* complex, from which *Pedostibes* may in turn be derived through only minor modifications. Tendencies leading to and continued within the *angusticeps* complex have been described. The derivative genera continue these same trends and in addition exhibit tendencies towards reduction in number, increase in size, and loss of pigmentation of the eggs; the tensor fasciae latae becomes elongate; all excepting *Ansonia* and *Pseudobufo* undergo modification of the vertebral column.

These trends are carried to different extremes in the various genera, and some genera exhibit apparently unrelated specializations of their own. But all of the major

TABLE I

SUMMARY OF DIAGNOSTIC CHARACTERISTICS

	Nectophrynoides	*Bufo*	*Pedostibes*	*Ansonia*	*Pseudobufo*	*Wolterstorffina*	*Mertensophryne*	*Pelophryne*	*Laurentophryne*	*Nectophryne*
Eggs small	*	×[1]	×	0	?	?	×	0	0	0
Eggs numerous	*	×[1]	×	I	?	?	I	0	0	0
Eggs pigmented	*	×	×	0	?	?	0	0	0	0
Tensor fasciae latae elongate	0	0	0	V	×	×	*	×	×	×
Adductor longus present	0	×	0	0	0	0	0	0	0	0
No. of presacral vertebrae	8	8	8	8	8	8	7	7	7	7
Cervical & 2nd vertebrae fused	0	0	0	0	0	0	0	×	0	0
Sacrum and coccyx fused	0	0	0	0	0	×	*	×	×	×
Cranial ornamentation	0	V	×	0	0	0	0	0	0	0
Frontoparietal and prootic fused	×	V	0	×	*	×	×	×	×	×
Quadratojugal of normal extent	×	×	×	0	0	0	×	0	0	0
Palatine present	×	×	×	×	×	×	×	0	I	0
Columella present	×	V	×	×	×	0	0	×	0	0
Generally reduced ossification	0	0	0	0	×	0	0	0	0	0
Omosternum present	×	0	0	0	0	0	0	0	0	0
Tips of phalanges expanded	×	0	×	×	*	×	0	×	×	×
Subdigital lamellae present	0	0	0	0	0	0	0	0	0	×

[1] Except *B. melanopleura*.

A cross (×) indicates possession of the characteristic stated, a zero (0) possession of an essentially opposite condition, the letter "I" an intermediate situation; the letter "V" indicates that the genus is variable with respect to the feature, a question mark (?) that information is not available; an asterisk (*) it used when some special feature or need for qualification or discussion exists, for which reference should be made to the text.

tendencies are carried to their extreme in *Nectophryne*; the sole exception is additional fusion of vertebrae in *Pelophryne*, a genus not as extremely modified as *Nectophryne* in most other respects.

The suggested relationships, based on these considerations, are shown in Figure 1. This interpretation necessitates the independent and parallel development of certain identical modifications in different lines. A notable instance is the loss of the adductor longus in *Nectophrynoides*, again in *Pedostibes*, and yet again in the *Ansonia-Nectophryne* complex. Reduction of the quadratojugal, of the medial arm of the pterygoid, and of the ear must each have occurred at least twice in the *Ansonia-Nectophryne* complex. However, a tendency towards reduction or loss of these elements is already apparent in its ancestry, even within the genus *Bufo*, and the fact that this has been carried to extremes in separate instances is not particularly surprising. Any scheme of relationships would require the assumption of parallel development of some features, and such parallels as are required in this scheme are more readily explicable than would be the assumption of parallel development of, for example, a long tensor fasciae latae in two independent instances, or independent modification of the vertebral column in two different lines, or others that would have to be assumed under any other concept or relationships.

LITERATURE CITED

BOULENGER, G. A. 1913. On the presence of two closely allied species of toads of the genus *Nectophryne* in Cameroon. *Ann. Mag. Nat. Hist.* (8th ser.), *12:70–71.*

GRIFFITHS, I. 1959. The phylogeny of *Sminthillus limbatus* and the status of the Brachycephalidae (Amphibia Salientia). *Proc. Zool. Soc. London, 132:457–487.*

INGER, ROERT F. 1954. Systematics and zoogeography of Philippine amphibia. *Fieldiana, Zool., 33:183–531.*

NOBLE, G. K. 1922. The phylogeny of the Salientia. I.-The osteology and the thigh musculature; their bearing on classification and phylogeny. *Bull. Amer. Mus. Nat. Hist., 46:1–87.*

RAMASWAMI, L. S. 1936. The morphology of the bufonid head. *Proc. Zool. Soc. London, 1936 (4):1157–1169.*

ROUX, JEAN. 1906. Synopsis of the toads of the genus *Nectophryne* B. & P., with special remarks on some known species and description of a new species from German East Africa. *Proc. Zool. Soc. London* for *1906:58–65, 2 pls.*

SCHMIDT, KARL P. AND ROBERT F. INGER. 1959. Amphibians exclusive of the genera *Afrixalus* and *Hyperolius. Exploration du Parc National de l'Upemba. Fasc. 56, 264 pp., 9 pls., map.*

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Herpetological Notes

GEOGRAPHIC VARIATION IN THE TADPOLE OF THE TOAD, *BUFO MARINUS*.—A series of 11 tadpoles and 13 recently metamorphosed toadlets (9–18 mm. in standard length = snout—vent length) were obtained by Dr. T. H. Lewis on June 24, 1955 along the edge of the Río Piaxtla, Sinaloa, México, near the point where the West Coast Highway (México 15) crosses the stream (approximately 46 air miles north of Mazatlán, Sinaloa.) Dr. Lewis has generously turned these specimens over to me for description.

The larvae are readily referred to *Bufo* on the basis of: eyes dorsal; spiracle sinistral; anus median; mouth parts complex; lateral margins of oral disk infolded at level of mouth; oral papillae restricted to sides of lips; labial denticle rows 2/3. Seven members of the genus, *Bufo alvarius* Girard, *Bufo marinus* Linné, *Bufo marmoreus* Weigmann, *Bufo mazatlanensis* Taylor, *Bufo occidentalis* Camerano, *Bufo punctatus* Baird and Girard, and *Bufo kelloggi* Taylor, are known to occur in Sinaloa. Allocation of tadpoles of this group to species without a full developmental series is extremely difficult.

The recently transformed toadlets in the Lewis material were compared with young or adult individuals of the known Sinaloan species in the collections of the Natural History Museum of Stanford University. Among the specimens examined was a series of tadpoles and toadlets obtained by the George Vanderbilt Foundation High Island Atoll Project from a bomb crater northwest of Aoekasaol village, Koror Island, Palau Group in the Micronesia area of the west Pacific. These *Bufo* were almost identical in every respect to my Mexican animals. The only species of the genus found on the Palau Islands is the introduced tropical American form *Bufo marinus*. Adults of the species are apparently common in the islands and a number of specimens are included in the uncatalogued material of the Vanderbilt Foundation at Stanford University. The similarity between the Palau and Mexican tadpoles and the abundance of *Bufo marinus* in the region where Dr. Lewis obtained his larvae leave little doubt as to the identity of the Sinaloan tadpoles. As no adequate study of the larval stages of Mexican *B. marinus* is available, my material is described in detail below (see Figs. 1–2). One specimen is at larval stage 33 and ten are at stage 37 (all stages mentioned in this report follow the system of Limbaugh and Volpe, *Amer. Mus. Nat. Hist. Novitates*, 1842, 1957.

Shape and form.—When viewed from above head and body broad, no marked constriction just posterior to eyes. From side body appears slightly convex in dorsal outline, flattened ventrally. Mouth at tip of head but inferior; nostrils lateral large, prominent, just anterior to eyes at point where snout slopes downward toward mouth; eyes moderate in size, dorsal, but nearer lateral margin of head than to midline when head viewed from above. Skin of upper and lateral surfaces of body relatively thin and opaque. Ventral skin very thin and nearly transparent as are tail fins. Anus tubular, median. Spiracle sinistral and placed far down on side of body, opening at about level of hindlimb insertion and far posterior to eye, although nearer to eye than to groin. Tail compressed with well-developed dorsal and ventral fins, dorsal fin gently curved; tip of tail rounded.

Mouth parts.—Mouth opening relatively large; upper jaw with a single denticulate horny beak, lower with a U-shaped denticulate beak. Labial denticle row formula 2/3; denticle row just above mouth narrowly interrupted; denticle row just below mouth longest of lower rows,

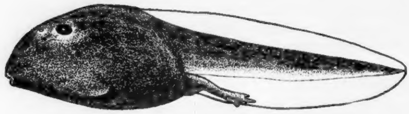

Fig. 1.—Tadpole of *Bufo marinus* from Sinaloa, Mxéico; lateral view.

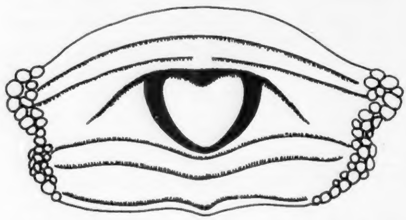

Fig. 2.—Mouth Parts of *Bufo marinus* tadpole from Sinaloa, México.

third row shortest. All labial denticle rows extend laterally to base of oral papillae. Margins of oral disk definitely indented at level of mouth. Papillae restricted to sides of oral disk, in two rows, except at level of marginal indentation where three rows may be present and along lower labial area where only one row is evident; papillae extending from a point slightly mediad to upper and outer corner of oral disk laterally, and ventrally down to a point ventral and mediad to outer edge of oral region; largest papillae adjacent to ends of denticle rows, smallest at corners of mouth; papillae not continuous above or below dorsal or ventral denticle rows along edges of labia.

Coloration.—Dorsum and sides of body dark blackish; skin of belly heavily pigmented with black but lighter than upper portions of body; ventral portion of spiracular tube unpigmented. A short, unpigmented area along midline of posterior region of body, just anterior to anus. Mouth and throat region with a few scattered fine punctations of dark pigment; labial denticles and beaks black. Tail musculature covered by black pigment dorsally and laterally, ventral margin light, without pigment. Tail fins transparent, unpigmented or with an extremely fine scattered mottling of dark pigment along upper edges of dorsal fin. Anal tube unpigmented.

Measurements.—see Table 1.

The Palau series of *Bufo marinus* tadpoles are all at stage 41 and agree with the description given above except that their gross general color is a dark brown instead of black and the labial papillae are in a single row along the lower labium over a slightly greater distance. The color difference is probably due to the manner of preservation. Measurements for the Palau tadpoles are given in Table 1. The toad-

TABLE 1

MEASUREMENTS OF TADPOLES OF *Bufo marinus*

Standard Length (snout-base of tail)	Tail Length	Snout to Spiracle	Width of Oral Disk	Snout to Nostril	Eye	Internarial Distance	Interorbital Distance
			Sinoloa (N = 11)				
8-11 (10.0)	10.5-15 (13.9)	5-7 (6.2)	2-3 (2.5)	1.5-3.5 (2.0)	1.5-2 (1.6)	1-1.5 (1.4)	1.5-2.5 (1.9)
	130-170 (141.9)	52-68 (61.9)	20-30 (24.8)	15-35 (20.9)	14-20 (16.3)	14-16 (15)	14-25 (20)
			Guatemala (N = 3)				
9-10 (9.7)	13-15 (13.8)	6-8 (6.8)	3-4 (3.3)	2 (2)	1-1.5 (1.2)	1.5 (1.5)	2-2.5 (2.2)
	135-150 (143.3)	60-80 (70.7)	30-40 (38)	20-22 (20.7)	10-16 (12)	15-16 (15.3)	20-27 (22.3)
			Palau Islands (N = 5)				
8.5-10 (9.1)	12-14 (12.9)	6 (6)	2-2.5 (2.0)	1.5-2 (1.9)	1-1.5 (1.2)	1 (1)	1.5 (1.5)
	133-156 (142)	60-72 (66)	22-28 (24)	17-23 (20.8)	11-15 (13.2)	10-18 (12.2)	15-18 (16.8)

Ranges and means (in parentheses) are first given in millimeters, followed by ranges and means as proportions of standard length.

lets in the series range in standard length from 8–12 mm., average 9.0 mm.

Breder (*Bull. Amer. Mus. Nat. Hist.*, 86 (8):394–397, 1946) has described presumed larvae of *Bufo marinus* from Darién, Panamá. The specimens upon which his brief account and figures are based are from the Río Chagres, taken between January 25 to 27, 1924 (AMNH 51803, illustrated in figure 6B), and in the vicinity of Yavisa between February 9 and March 27, 1924 (AMNH 51807, figures 6A, 6C, 6D, 6E, 7). Examination of Breder's material, including the illustrated examples, reveals that his figures are highly inaccurate in details of morphology and coloration. Although the specimens are in poor condition, they appear to be typical *Bufo* tadpoles with small nostrils, transparent tail fins, and spiracular opening at level of hindlimb insertion. The dorsal tail fin is high anteriorly, sloping rapidly posteriorly to form a pointed tip. Mouth parts agree with Breders' figure 6E. The throat region is heavily pigmented with black; ventral portion of spiracular tube unpigmented; no pre-anal unpigmented area along ventral midline; considerable pigment scattered throughout dorsal tail fin; tail musculature covered by black pigment dorsally and laterally, its ventral margin light, without pigment.

Differences between tadpoles of distinct species within the genus *Bufo* are usually slight and generally involve subtle differences in mouth parts, tail structure and coloration. Breder's Panamá series differs rather markedly from Sinaloan *B. marinus* in nostril size, tail shape and pigmentation, and in pigmentation of the throat and ventral regions (see Table 2). The degree of difference thus involves more striking characteristics than are frequently used to distinguish between the tadpoles of many species of *Bufo*.

Bufo larvae from Esquipulas, Departmento de Chiquimala, Guatemala, obtained in a sluggish stream, are almost certainly *marinus* since the only other toads known from the area, *Bufo coccifer* Cope and *Bufo valliceps* Wiegmann, have entirely different larvae. The three examples, 9 to 10 mm. in standard length, are at stage 33 and agree in most particulars with the sample from Sinaloa. However, the Guatemala larvae differ markedly from the Mexican tadpoles in nostril size, denticle tooth row proportions, and coloration. In the nostril and coloration characters these individuals resemble rather closely Breder's Panama specimens. A comparison of the Mexican, Guatemalan and Panamanian samples is given in Table 2 and in Figure 3.

The Guatemala series of *marinus* bridges the gap between Panamá and Sinaloa larvae to such a degree that there is no reason to suppose that more than one species is involved. Whether the points of difference noted are indicative of distinct genetic populations or are due to local environmental conditions cannot be determined. In view of the usual stability of *Bufo* larval characteristics, the subtle but consistent differences between Panamá, Guatemala, and Sinaloa tadpoles of *marinus* lend some support to the assertion of Taylor and Smith (*Proc. U.S. Nat. Mus.* 95:551, 1945) that this species may be a composite of at least several allopatric forms. The very close resemblance between the Sinaloan and Palau larvae, in the light of the differences between the Mexican and Middle American samples, suggests that the Palau population originated from toads introduced from the west coast of México.

TABLE 2

CHARACTERISTICS OF SAMPLES OF LARVAL *Bufo marinus*

Sinaloa	Guatemala	Panamá
1. Nostrils moderate	nostrils small	nostrils small
2. 2nd lower denticle row shorter than 1st	2nd lower denticle row longer than 1st	2nd lower denticle row shorter than 1st
3. Tip of tail rounded	tip of tail rounded	tip of tail pointed
4. Throat region with scattered pigment	throat region black	throat region black
5. A definite pre-anal light area on ventral midline	no pre-anal light area	no pre-anal light area
6. Dorsal tail fin with hardly any pigment	dorsal tail fin with considerable pigment	dorsal tail fin with considerable pigment
7. Ventral light area of tail musculature extensive	ventral light area of tail musculature reduced	ventral light area of tail musculature reduced

Material utilized in the preparation of this paper was made available by Dr. Thomas H. Lewis, United States Navy Hospital, Bethesda, Maryland; Mr. Harold E. Munsterman, Natural History Museum, Stanford University; Dr. Laurence C. Stuart, University of Michigan; and Dr. Richard G. Zweifel, American Museum of Natural History. Their aid is much appreciated. Mr. Russell D. Cangialosi of Los Angeles and Mrs. P. H. Starrett of the University of Southern California prepared the illustrations of the *Bufo marinus* tadpoles.—JAY M. SAVAGE, *Department of Biology, University of Southern California, Los Angeles 7, California.*

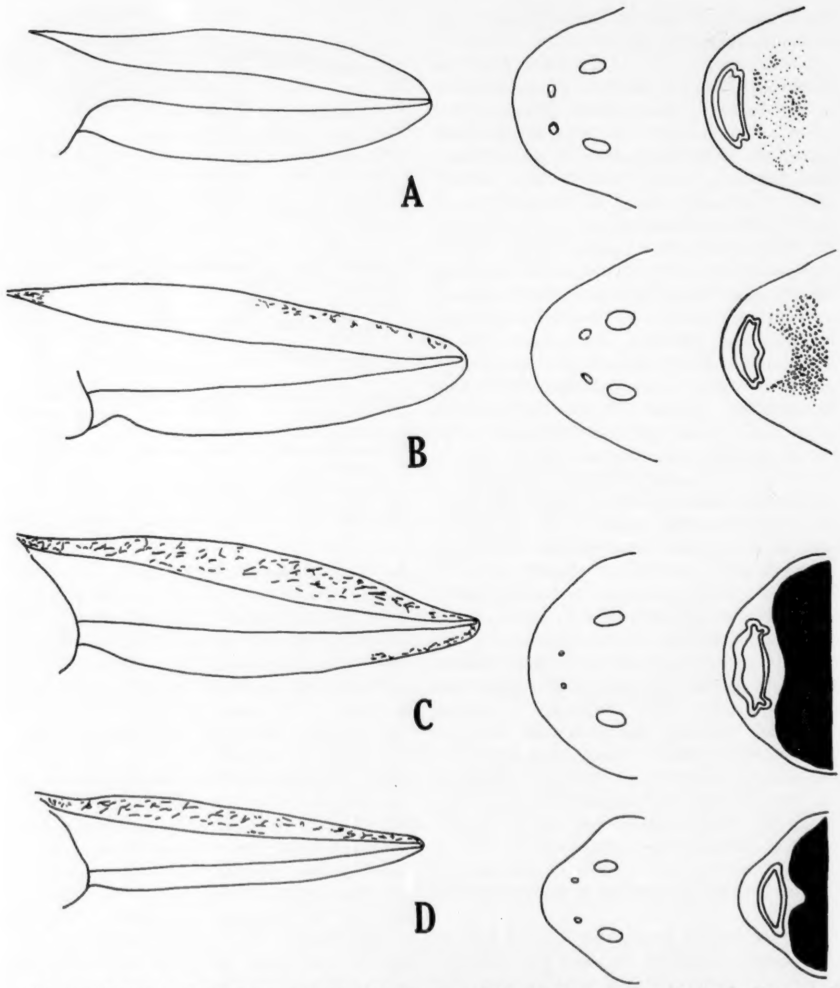

Fig. 3.—Variation in Characteristics of Larval *Bufo marinus*. A. Palau Islands B. Sinaloa, México C. Guatemala D. Panamá. Illustrated from left to right are: tail, dorsal region of anterior portion of head, ventral view of anterior head region.

HEART RATES OF UNANESTHETIZED SNAKES BY ELECTROCARDIOGRAPHY.—Klauber (*Rattlesnakes, Their Habits, Life Histories and Influence on Mankind. p. 316*, 1956), after observing the exposed hearts of rattlesnakes, concluded that a heart rate of about 45 beats per minute was normal for a live, intact rattlesnake. His studies were carried out immediately after decapitation, when subsequent body movements had ceased. No evidence was presented to support the assumption that the heart rate observed in such a procedure corresponded to that of the living snake. Cowles and Phelan (COPEIA 1958(2):77–83) have reported the heart rates of living rattlesnakes obtained by electrocardiogram from implanted electrodes. We believe, however, that the implanted electrodes may irritate the snake to such an extent that it may never reach basal condition. The technique described here was been used successfully for obtaining the heart rate of intact, unanesthetized snakes from external strap electrodes; the specimen is otherwise undisturbed.

Method.—One species of *Constrictor*, one crotalid species, and five kinds of native colubridae snakes were used in this study. The animals were

housed in wooden and glass cages in an air-conditioned room maintained at 23–27°C. They were fed dead mice or rats every seven days, and all specimens appeared in good health throughout the test period.

The electrodes consisted of from 30–75 cm. of braided shielding stripped from microphone cable. Just prior to application, the electrodes were covered with a thick layer of electrocardiograph electrode paste. The braid was then wrapped twice around the snake's body and the ends were twisted together. To assure good electrical conductivity, more paste was applied to the attached electrode. A 40 × 5 cm. strip of rubber dam was then lightly stretched and tied around the braid in order to firmly hold it in position.

Two electrodes were used, one around the neck and the other around the center of the body. The electrodes thus spanned the heart and measured the electrical potentials that spread over the heart with each beat. The signals received at the electrodes were picked up by clip leads attached to the twisted braid ends, and were amplified by a two-stage transistor preamplifier. In order to reduce 60 cps noise the signals were then passed through an electronic filter which reduced the high frequency response to about 40 cps. The cardiograms were recorded on a Brush Development Company direct-writing oscillograph (Amplifier No. BL-928; Oscillograph No. BL-202). The low frequency time constant of the instrument was 0.1 sec. The transistor preamplifier and Brush recorder were used instead of a conventional electrocardiograph instrument, although the latter would have served as well.

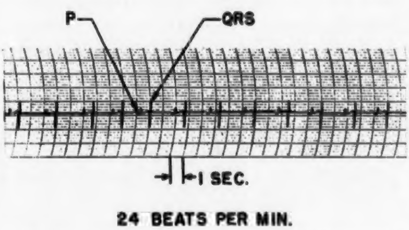

Fig. 1.—Interpretation of cardiogram of *Coluber constrictor flaviventris*.

Results.—The cardiograms were interpreted on the same basis as mammalian electrocardiograms. The ophidian heart consists of two separate atria and a single ventricle which is partially divided by an incomplete septum. The oscillograph pattern is shown in Fig. 1. The small deflection is probably the P wave, which precedes auricular contraction. The QRS wave is at the beginning of verticular contraction. The T wave probably was not detected in the charts because its low magnitude and low frequency components could not be reproduced by the instrument used in these studies. The chart rate was one division per second.

The highest heart rates were obtained immediately after the electrodes were applied, probably because of the excitement caused by handling. A rate of 72 beats per minute, the highest recorded, was from a *Lampropeltis getulus holbrooki* during the first minute of test. Nine beats per minute, the lowest heart rate obtained, was recorded from a *Pituophis melanoleucus sayi* 2 hr. and 16 min. after the electrodes had been applied.

Table 1 shows the highest and lowest heart rates measured for five kinds of native colubrid snakes. All specimens were young or near adult. The temperature was 24°C during all the observations, with the exception that the highest rate for the *Elaphe o. obsoleta* was recorded at 28°C. This was not due to the effect of temperature alone, since this snake was handled immediately prior to the observation.

TABLE 1
HEART RATES OF NON-POISONOUS SNAKES

Species	Length	Weight	Sex	Known Period of Captivity	Beats Per Minute	No. of Days Since Last Feeding
Pituophis melanoleucus sayi	168 cm.	1126 g.	♂	8 Months	Hi. 54	4
					Lo. 9	4
Elaphe obsoleta obsoleta	152 cm.	1050 g.	♂	20 Months	Hi. 70	4
					Lo. 26	4
Lampropeltis getulus californiae	99 cm.	182 g.	♀	12 Months	Hi. 52	3
					Lo. 38	3
Lampropeltis getulus holbrooki	71 cm.	140 g.	♂	16 Months	Hi. 72	5
					Lo. 30	5
Coluber constrictor flaviventris	112 cm.	275 g.	♀	12 Months	Hi. 64	5
					Lo. 23	5

TABLE 2
HEART RATES OF ADULT *Constrictor c. constrictor*[1]

Observation No.	Beats Per Min.	Temperature	Time in Min.
1	15	23°C	0
2	15	23°C	30
3	13	22°C	60
4	13	22°C	90
5	11	21°C	120
6	12	19°C	150
7	12	18°C	180
8	12	18°C	210
9	12	18°C	240

Q_{10} = 1.3 on [illegible]
Can't fit curve

[1] This specimen was a male, weighing 4,313 g. and measuring 220.7 cm.

The heart rates of an adult *Constrictor c. constrictor* were recorded over a four–hr. period (Table 2). During this time the cage temperature was reduced 5°C, and the heart rate decreased from 15 to 12 beats per min. The external electrodes were applied around the second and fourteenth dark irregular crossbands.

Electrocardiograms were recorded from an adult male *Crotalus ruber ruber*, 130 cm. in length and 1,234 g. in weight. The lowest heart rate obtained was 16 beats per min. (Fig. 2). On numerous occasions this specimen registered rates between 16 and 20 beats per min. for periods as long as 1 hr., with the temperature between 21.5 and 23°C. With the temperature at 28°C, a heart rate of 54 beats per min. was recorded immediately after application of the electrodes. The specimen was constantly moving about and hissing.

The electrocardiogram of the rattlesnake during a provoked strike is shown in Fig. 3. The specimen stretched one-third of his body length with his head approximately 40 cm. above the floor of the testing chamber. He then thrashed about and struck at the electrode around the middle of his body. Close examination revealed that the electrode had worked underneath one of the ventral scutes and apparently irritated the snake. One minute before the strike his heart rate was 31 beats per min.; during the 60-second interval in which the strike occurred it was 37; it increased to 46 immediately after the strike. Seven minutes later it had dropped to 34 beats per min. The temperature during this time was 24°C.

The heart rate of 16 beats per min. for a *Crotalus ruber* is considerably lower than the lowest "resting" rate of 35 beats per min reported by Cowles and Phelan. During the entire period of observation the overhead light was on and the senior author was present in the laboratory and within full view of the rattlesnake at all times. The specimen evidently was not disturbed by the actions of the observer in recording and manipulating the apparatus. The heart rate of the snake increased to 34 beats per min. when the top of the testing chamber was pounded on. The highest heart rate of 54 beats per min. is 6 beats per min. below the highest "fear rate" obtained by Cowles and Phelan when they exposed a *Crotalus ruber* to extracted king snake odor.

Approximately 15 to 25 observations were made on each specimen. The highest heart rates usually occurred immediately after the specimen had been handled or disturbed. In most cases a basal condition was reached within 30 min. There were no notable differences in the tests run with the laboratory lights on or off, during various periods throughout the day, or with the observer either present or absent from the beginning of each test. However, if the observer entered or left the room during the observational period, the heart rates increased.

This investigation was supported by C. A. Johnson, M.D. of Lemmon, South Dakota. The authors wish to express their appreciation to the Swope Park Zoological Gardens for their generous cooperation and to Mr. Burton Baldwin and Dr. Louis H. Goodson of Midwest Research Institute for their help and encouragement.—GARY K. CLARKE AND THOMAS I. MARX, *Midwest Research Institute, 425 Volker Blvd., Kansas City, Missouri.*

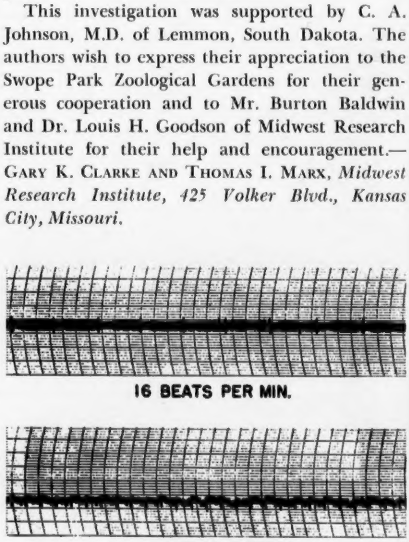

Fig. 2.—Extreme rates from *Crotalus ruber ruber*.

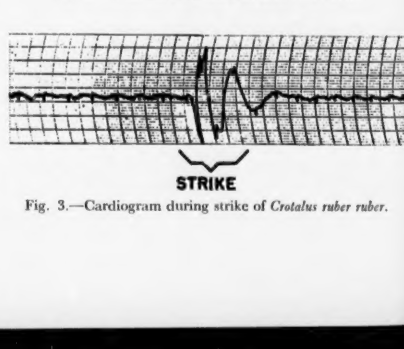

Fig. 3.—Cardiogram during strike of *Crotalus ruber ruber*.

REPRODUCTION IN A PAIR OF CORN SNAKES, *ELAPHE GUTTATA GUTTATA*.— This report deals with a complete reproductive sequence in a pair of captive corn snakes. The female is approximately 108 cm. in length and was taken at Gainesville, Alachua County, Florida. The male is approximately 91 cm. long, and was caught at Otter Creek, Levy County, Florida.

Courtship and Copulation.—The female was captured December 1, 1955, and isolated until May 24, 1959, when the male was put into the cage at 1:50 PM. The male immediately showed interest in the female and began to explore the anterior part of her body. The female then began to investigate the anterior part of the body of the male. After about two minutes of this activity both male and female started to jerk their heads simultaneously. The head-jerking alternated with exploratory activity and ended at 1:55 PM as the male brought the left side of his tail along the right side of the tail of the female. During copulation he kept most of his body on top of the female. The tails of both animals twitched rapidly; otherwise they lay still. At 2:05 PM the male withdrew his hemipenis.

Between May 25–26 the snakes showed little interest in each other, and I believe that no sexual activity took place. On May 27 at 9:30 AM the male again began to investigate the female. As before the female began to explore the body of the male, and soon simultaneous head-jerking took place. At 9:25 AM the male brought the right side of his tail in contact with the left side of the tail of the female, and inserted his right hemipenis into her cloaca. The male was more active during this second copulation. He kept most of his body draped over the female and rubbed the ventral surface of his neck over her back. This activity has been recorded as courtship behavior in several species of snakes, but took place during copulation in the above animals. At 9:46 AM the male removed his hemipenis, which remained everted and engorged with blood. At 9:49 AM the male inverted his hemipenis. MacMahon (COPEIA 1957(3):232) reported more complicated courtship in three matings between a pair of captive corn snakes from the Florida Everglades.

Oviposition.—The female began to lay June 28, 1959, after a 35 day gestation period. Groves (*Herpetologica* 13(1):79–80,1957) has reported a gestation period (interval between copulation and oviposition) of 37 days, and Bechtel (COPEIA 1958(2):148–149) periods of 54, 56, and 68 days for *E. guttata*.

When first observed at 9:10 AM, the female had laid five eggs and was delivering the sixth. By 12:05 PM the thirteenth and last egg was laid. They were deposited in an adherent clutch of three vertical rows. The female kept part of her body coiled around the eggs during oviposition.

The clutch was removed at 2:00 PM and placed in a gallon jar. Nine of the eggs ranged in length from 29–37 mm., and in width from 16–18 mm. The clutch weighed 92.3 grams.

Incubation.—The eggs were incubated at temperatures ranging from about 80–90°F. The clutch weighed 98.0 grams on July 5, 100.2 grams on July 19, and 98.7 grams on July 25. Several eggs looked wrinkled and desiccated on the last date.

After 34 days, an egg that had a markedly wrinkled appearance was opened. It contained a living embryo that died within a few minutes. The head of this animal measured 10 mm., the post-cephalic region 40 mm.

After 58 days of incubation another wrinkled egg was opened. It contained a perfectly formed, living snake that made rather convulsive movements and extruded its tongue, but lived only about 15 minutes.

On August 28, after an incubation period of 61 days, the eggs began to hatch. MacMahon, Groves, and Bechtel record incubation periods of 71, 59, and 73 days for corn snakes.

Hatching.—The first snake was seen emerging from an egg on the bottom row at 1:55 PM, August 28. At 3:20 PM the snake had its head completely out of the small slit in the egg shell. Movement by the observer caused the snake to pull its head back into the egg. By 4:40 PM movement was noted in an egg in the middle row, and by 5:20 a head emerged from this egg. At 10:25 PM both snakes were back in their respective eggs.

At 12:00 PM, August 30, the snake that first showed activity had hatched. At this time slits were noticed in all the eggs, and heads were thrust out of all but five or six of the eggs. Within the next hour all of the snakes with the exception of four had hatched. The four remaining eggs were opened and contained dead snakes. All of the newly hatched snakes coiled and vibrated their tails when disturbed by the observer.

On September 2 the eyes of the hatchlings became cloudy. On September 7 the first snake had shed its skin, and by September 11 all but one of the snakes had shed. MacMahon reports that his young corn snakes began to shed 11 days after the first snake had hatched.—J. ALAN HOLMAN, *Department of Biology, University of Florida, Gainesville, Florida*.

RANGE EXTENSION OF *ASCAPHUS TRUEI* IN IDAHO.—Previous captures of *Ascaphus truei* in Idaho have been limited to Benewah, Latah, Shoshone, Clearwater, Adams, and Washington counties. Recent discoveries of the tailed frog in Kootenai, Valley, and Custer counties extend the known range north, south, and southeast.

On August 9, 1958, two *Ascaphus* larvae and one metamorphosing juvenile were found in a drying stream in Kootenai county. This unnamed stream flows into Coeur d'Alene Lake at the western end of Beauty Bay. The surrounding area is heavily forested with dwarf maple, red fir, and ponderosa pine. In June of 1959, a 22 mm. male was found under a small rock near the edge of this same creek.

Seven of this year's *Ascaphus* larvae, and one of the previous year's were found under rocks in Trail Creek in Valley County, T 14N. R 10E., four miles west of Warm Lake, on July 3, 1959. Three more larvae were captured in Big Creek at Big Creek Summit, eight miles west of Warm Lake. All of these larvae were located on the under surfaces of rocks just below a small riffle or pool. The elevation at Big Creek Summit is 6,608 feet. The water temperature was 14°C. The area surrounding the stream is brushy and forested with pine, fir, and spruce. No adults were found in Valley County.

The larvae-of-the-year from Valley County were grey, speckled with pink, and had a pink blotch at the tip of the tail, while the year-old larvae were mottled brown with a pink blotch at the tail tip. The older larvae were 43 and 35 mm. in total length by 12 and 9 mm. in width across the widest part of the body. The younger larvae ranged from 20 by 4 mm. to 24 by 6 mm.

Many more tadpoles were found on a second trip to Trail Creek on August 4, 1959. A rosary-like string of 14 unpigmented *Ascaphus* eggs was attached to the under surface of a large rock in a rather deep area of Trail Creek. Two adults were seen near this site, but quickly swam down stream and out of view. The temperature of the water at Trail Creek was 9° C at 11:30 on the summit and 11° C at 12:30 four miles down stream. At the North Fork of Deer Creek, also in Valley County, T 12N. R 7E., 26 more larvae were found. No adults were seen in this stream.

In the extreme western section of Custer County, eight *Ascaphus truei* larvae were captured in Cape Creek, T 12N. R 10E. The largest of these larvae was 40 mm. in total length by 14 mm. in width. Pine and fir trees dominate in this area, while a few miles to the south a more arid area is present.—CARL D. CORBIT, *Department of Biological Sciences, University of Idaho.*

SOME HEMATOLOGIC AND BIOCHEMICAL FINDINGS IN *HELODERMA HORRIDUM,* THE MEXICAN BEADED LIZARD.—During the course of an investigation into certain characteristics of the venom of *Heloderma horridum,* we had an opportunity to make a number of observations on the blood and plasma of two animals of this species. The test findings are herein recorded.

The beaded lizards were sexually mature females that had been in captivity for over a year. The snout-vent length was 34.6 cm. for the fat, larger animal and 25.9 cm. for the lean, smaller one. The latter specimen was housed in the same cage with other beaded lizards, but was apparently less aggressive and possibly deprived of some of its share of food.

The studies were performed in October, 1959, 1 and 3 days, respectively, after the animals had been subjected to the venom collection procedure. During this interval the animals were fasted and without access to water. In order to enhance safety of handling during the procurement of blood for study, each animal was placed in a deep freeze compartment for a few minutes. When torpid, it was removed and a mid-line ventral incision quickly made. Ventricular blood was obtained and aliquots were placed immediately in glass test tubes containing heparin or balanced oxalate for separation of cells from plasma, or in plain tubes for the collection of serum. Sixteen ml. of blood were obtained from the larger animal while the smaller specimen yielded only 9 ml.

The findings in tests on blood from the larger animal were as follows: hemoglobin, 9.0 gm.% (cyanmethemoglobin method); erythrocytes, 500,000/c.mm.; hematocrit, 29.5%; urea nitrogen, 1.0 mg.% (Boutwell, *Clin. Chem. 3:205–216,* 1957); glucose, 45 mg.% (Nelson, *J. Biol. Chem. 153:375–380,* 1944). In serum, the sodium was 157 mEq. (Barnes, et al, *Ind. Eng. Chem. Anal. Ed. 17:605–611,* 1945; Berry, et al, *ibid., 18:19–24,* 1946); potassium, 3.7 mEq. (*ibid.*); and chlorides, 118 mEq./liter (Schales and Schales, *J. Biol. Chem. 140:879–884,* 1941). The total plasma copper was found to be 196 micrograms % (Natelson, *Microtechniques of clinical chemistry,* pp. *182–185*), with 7.7 micrograms of unbound copper (Gubler, et al, *J. Biol. Chem. 196:209–220,* 1952).

For the smaller animal, the findings were: hemoglobin, 6.8 mg.%; hematocrit, 21%. The following were plasma determinations: sodium, 159 mEq./liter; potassium, 5.5 mEq./liter; chlorides, 109 mEq./liter; urea nitrogen, 3 mg.%; glucose, 0.2 mg.%. It may be that the extremely low blood glucose of this animal reflected its

poor nutritional state possibly aggravated by the period of fast, at least 72 hours, which preceded the collection of its blood.

The hemoglobin of both animals was subjected to paper electrophoresis on a Spinco R_2 model electrophoretic apparatus at pH 8.6 in Spinco buffer B-1, run at 250 volts for 18 hours. As can be seen in Fig. 1, *Heloderma* hemoglobin migrated at about the same rate and distance as human hemoglobin C. Of interest also was the finding that about 20% of the hemoglobin of both animals was resistant to alkali denaturation (Singer, et al, *Blood 6:413–428,* 1951) suggesting it was "fetal" hemoglobin of this species.

The paper electrophoresis of the plasma proteins of the larger animal was compared to that of normal human plasma (Fig. 2). The technique differed in that Spinco buffer B-2 was used and the run was for 16 hours. The strips were handled according to the method of Jencks, et al, (*Biochem. J., 60:205–215,* 1955) and were scanned on a Spinco Analytrol. It can be seen that 2 fractions migrate the same as fibrinogen and β globulin of human plasma. There is a

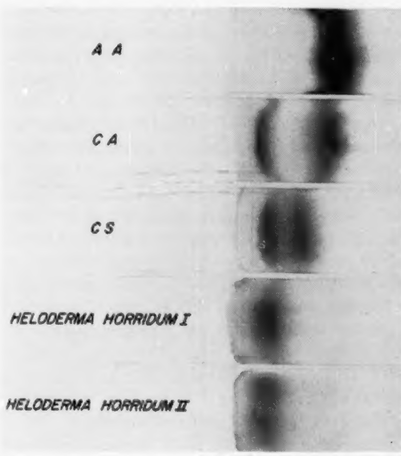

Fig. 1.—Electrophoretic patterns of hemoglobin from *H. horridume* are shown (the 2 lower paper strips) as are normal human hemoglobin (AA), hemoglobin CA, and sickle cell-C hemoglobins.

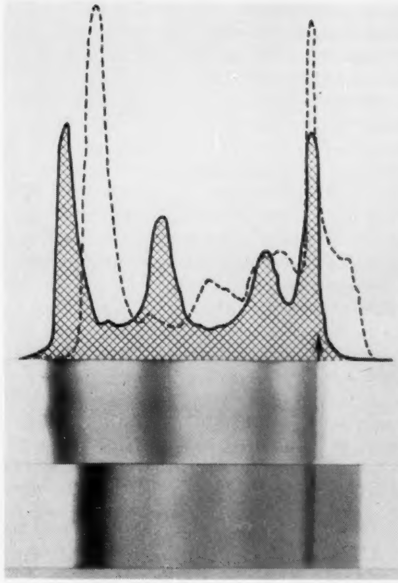

Fig. 2.—Electrophoretic pattern of plasma from *Heloderma horridum* (cross-hatched tracing and upper paper strip) contrasted with that of human plasma (dotted line tracing and lower paper strip).

high peak, however, which lies predominantly between the α_1 and α_2 areas of human plasma. A small component is evident between this peak and that which is taken to be albumin. The latter migrates farther than does human albumin. The pattern obtained with *Heloderma* plasma resembles that described for lizards by Dessauer and Fox (*Science, 124:225–226,* 1956).

We are indebted to the Wyeth Laboratories, Radnor, Pa. for making these animals available, and to Mr. Roger Conant, Director, and Mr. Edward Endy of the Philadelphia Zoological Gardens for their cooperation in the housing and care of these animals.—CHRIS J. D. ZARAFONETIS AND JOHN P. KALAS, *Department of Medicine, Hematology Section, Temple University Medical School, Philadelphia, Pa.*

Ichthyological Notes

GROWTH OF THE CENTRAL JOHNNY DARTER, *ETHEOSTOMA NIGRUM NIGRUM* (RAFINESQUE) IN AUGUSTA CREEK, MICHIGAN.—Life history studies of the johnny darters, *Etheostoma olmstedi* and *Etheostoma longimanum,* have been reported by Raney and Lachner (1943, *Amer. Midl. Nat. 29(1):229–38*), but little ecological work has been done on the

central johnny darter, *Etheostoma nigrum nigrum*, in the smaller streams and lakes. Trautman (1957, *The fishes of Ohio. Ohio State Univ. Pr. pp. 565–7*) has summarized the most extensive ecological data for this subspecies.

Seining collections were made each month from March 1957 through November 1958, in Augusta Creek, a typically postglacial stream of southern Michigan. Eighteen associated species were collected, among which *Semotilus*, *Rhinichthys*, and *Notropis* were the three most abundant genera represented. Collections from each of three distinctly different ecological stream types were compared. These types were recognized as pools (depth 20″, ½ ft./sec. flow with sandy bottoms); riffles (depth 6″, 1 ft./sec., pebbly bottom); and rapids (depth 8″, 2 ft./sec., bottom stony to rocky, algal growth abundant). The central johnny darter preferred weedy pools first, riffles secondly, and was only occasionally taken in rapids, this latter habitat being occupied by the rainbow darter, *Etheostoma caeruleum*. Pools produced 63 percent, riffles 24, and rapids 13, of the johnny darters taken. No significant difference in mean standard length or sex ratios per age-group was noted between samples from different ecological habitats. There was, however, a definite trend toward greater longevity among age-group III females.

Table 1

Length Frequencies for Each Age Group of 556 Specimens *Etheostoma nigrum nigrum* Taken in Augusta Creek, Michigan, in the Fall of 1957

Standard Length mm.	Age-Groups (Winters of life) O M	O F	I M	I F	II M	II F	III M	III F
22	1	6	—	—	—	—	—	—
24	11	12	—	—	—	—	—	—
26	34	39	—	—	—	—	—	—
28	35	46	—	—	—	—	—	—
30	16	25	—	—	—	—	—	—
32	18	7	—	—	—	—	—	—
34	9	6	—	1	—	—	—	—
36	4	2	3	6	—	—	—	—
38	3	2	12	30	—	—	—	—
40	—	—	10	32	—	3	—	—
42	—	—	18	32	—	1	—	—
44	—	—	26	18	3	5	—	—
46	—	—	15	10	3	8	—	—
48	—	—	10	4	5	—	—	1
50	—	—	3	1	3	4	1	—
52	—	—	2	—	1	1	1	1
54	—	—	1	—	3	—	—	—
56	—	—	—	—	—	—	—	1
58	—	—	—	—	—	—	—	1
No. of Specimens	131	145	100	134	18	22	2	4
Mean	28.7	28.5	43.9	41.4	49.3	46.0	—	—
Range	22–39	22–39	36–55	34–51	44–55	40–53	—	—
S. D.	3.6	3.0	3.7	3.0	3.3	3.3	—	—

Table 2

Length of Central Johnny Darter Males Age-Group I and for Both Sexes Age-Group O, Augusta Creek, Michigan 1957

Month	Males Age-group I No. Exam.	Mean S.L. mm.	Range	Both Sexes Age-group O No. Exam.	Mean S.L. mm.
April 15	35	27.8	22–40	—	—
May 9	25	33.5	24–37	—	—
May 18	21	33.9	31–38	100	5.0 (hatching)
May 28	38	34.9	29–42	—	—
June 15	42	35.6	32–48	25	16.8
July 17	34	41.2	37–50	95	23.0
Aug. 9	31	42.5	39–50	161	26.2
Sept. 28	53	42.6	36–50	104	27.5
Oct. 13	16	42.3	36–52	53	28.5
Nov. 23	30	43.6	36–50	44	29.2

Age and rate of growth.—During September, October, and November of 1957, 556 darters were collected from 10 stations over 14 miles of stream. The frequency distribution and mean standard length for each age-group is presented in Table 1. Both sexes attain a standard length of 28 mm. by the end of their first summer. During their second summer, males grow at a somewhat faster rate. This is true in the third summer. Thus the mean standard length for age-group I fish is: males-43.9 mm., females-41.4 mm.; age-group II: males-49.3 mm., females-46.0 mm. More females than males in this sample survived their fourth and last summer of life.

Growth through the 1957 season, beginning about mid-March, is shown in Table 2. During the spawning (and hatching) season, growth differences were observed between adult and newly-hatched fish. During the spawning period May 10 to June 15, age group I males grew only 2 mm. in length. Yet for periods of 30 days before, and after this spawning season, these fish grew 6.1 mm. From July through September 28 very little growth was made. Within the same period, young-of-the-year fish continued to grow at their normal rate of about 0.6 mm. per day and achieved a length of 11.8 mm. Because both mature fish and fry were subject to the same

water temperature fluctuations, it would appear that this growth-differential has a spawning rather than a water temperature correlation. Both age-groups obtained about 80 percent of their year's growth before July 15. After September 30, little or no growth is achieved until the following spring.

Comparison of 1957 and 1958 fry.—Hankinson (1908, *Geol. Surv. Mich. Rept. 1907:157-288*) gave the spawning period for southern Michigan for *Etheostoma n. nigrum* as May 16 to June 19, when the stream temperature has reached 15°–18° C. In Augusta Creek, the beginning spawning dates vary greatly from year to year. In 1957 spawning began on May 10 and in 1958 on April 15, giving the latter fry a longer growing period of 25 days. Standard length comparisons were made on fry taken on the same dates in June, July, August, and September for both years. Despite the longer growing season in 1958, both fry achieved approximately the same length at the end of the first growing season. Thus the mean standard lengths for August were 26.3 mm. and 25.5 mm.; for September 28.1 mm. and 28.9 mm., 1957 and 1958, respectively.

In 1958 following unseasonably warm days in April when the temperature reached 70°F., there occurred a cold cloudy period for about three weeks. Growth may have been retarded until about May 10 in the case of the young of the 1958 season.

Acknowledgments.—I wish to thank Drs. Peter I. Tack and Clarence L. Schloemer for their valuable suggestions and guidance during this study. The research was supported in part by a National Wildlife Federation Grant.—EDWARD P. SPEARE, *Department of Zoology, Michigan State University, East Lansing, Michigan.*

NOTES ON WESTERN NORTH ATLANTIC SHARKS, No. 2.—The data reported here chiefly bear on the distribution of western North Atlantic sharks. They come from a variety of sources and the author is indebted to the following people for help in accumulating them: Mr. Norman Benson, Vineyard Haven, Mass.; Mr. George Berglund, U. S. Fish and Wildlife Service, Provincetown, Mass.; Mr. Russell Boardman, Mattapoisett, Mass.; Dr. Robert L. Edwards, USFWS, Woods Hole, Mass.; Dr. Robert H. Gibbs, Boston University; Mr. Robert Leahy, Woods Hole, Mass.; Capt. Norbert Macara, Provincetown, Mass.; Mr. James L. Squire, Jr., USFWS, Gloucester, Mass.; Mr. Samuel Vincent, now of Lewes, Delaware; Mr. Milton Welt, S. Harwich, Mass.; and Messrs. Frank J. Mather, III, Stanley E. Poole, William E. Schevill, and William C. Schroeder all of the Woods Hole Oceanographic Institution. I would also thank the officers and crews of the Research Vessels ATLANTIS, ASTERIAS, BEAR and CRAWFORD of W.H.O.I. and of the USFWS vessel DELAWARE. This note is Contribution No. 1076 from the Woods Hole Oceanographic Institution.

Lamna nasus (Bonnaterre), mackerel shark. The following longline captures were made on exploratory fishing cruises of the R/V DELAWARE of the United States Fish and Wildlife Service. Depth of capture could have been at any depth from about 100 meters to near the surface. The identifications were made by F. J. Mather, III.

On January 23, 1959, at 37°30′N, 71°33′W, a female, 112 cm. in total length, and on May 20, 1959, at 38°42′N, 68°32′W, a male, 98 cm. in total length were taken. Both of these records, which came from near the 2000-fathom curve, are of interest since *Lamna nasus* is generally considered to be a shark of the continental shelves, there being no records of it in the western North Atlantic from deep water, save one just off the shelf near Sable Island Bank (Bigelow and Schroeder, 1948, *Fishes of the western North Atlantic, 1:118–9*). The rather small size of these specimens is also of interest.

Isurus oxyrinchus Rafinesque, mako shark. Since the distribution of this shark is not well understood, a summary of seven long-line captures made during exploratory fishing cruises by the R/V DELAWARE is given in Table I. Depth of capture could have been at any depth from about 100 meters to near the surface. Cephalopod and fish remains (including an *Alepisaurus*), and in one case some pieces of salps, were found in the stomachs.

Carcharodon carcharias (Linnaeus), white shark. To recent records of this species for the New England coast (Scattergood and Coffin, 1957, COPEIA: *155*; Backus, 1957, COPEIA: *246*; Bigelow

TABLE 1

RECORDS OF *Isurus oxyrinchus* MADE ON R/V DELAWARE CRUISES

Position	Date	Sex	Total Length (cm.)
38°58′N, 66°26′W	June 9, 1957	M	166
37°45′N, 66°32′W	June 10, 1957	M	131
37°30′N, 68°10′W	June 12, 1957	F	205
42°18′N, 64°02′W	Sept. 11, 1957	F	176
40°34′N, 64°02′W	Sept. 12, 1957	M	200
38°49′N, 68°00′W	May 21, 1959	M	201
38°37′N, 68°24′W	May 24, 1959	M	158

and Schroeder, 1958, Copeia: *54*; and Scattergood and Goggins, 1958, *Marine Field Naturalist, 14:40*) the following may be added. A male, 188 cm. in total length, was taken in a fish trap off Quisset Harbor, Woods Hole, Mass. on May 29, 1958. According to Mr. Robert Leahy, Marine Biological Laboratory, Woods Hole, another specimen of the same kind and of about like size was taken in the same trap on May 31, 1958.

On July 6, 1959, an immature female 278 cm. in total length was taken in the same trap. The dressed weight of the animal was about 115 kg. The head, fins, and viscera were estimated as weighing from 35 to 45 kg. so that the total weight was likely between 150 and 160 kg. The stomach contained fish remains including an intact menhaden about 30 cm. long.

On September 2, 1959, an immature male, 189 cm. in total length, was harpooned at the surface about two miles south-southeast of West I., Buzzards Bay, Mass. by Mr. Russell Boardman of Mattapoisett, Mass. The claspers were about 17 cm. long and extended about 10 mm. past the tips of the pelvic fins. This animal weighed 78.4 kg.

On September 5, 1959, a newly-dead male specimen, 169 cm. in total length, was found on Red River Beach, South Harwich, Mass. The claspers were about 12 cm. long and extended about 10 mm. beyond the tips of the pelvic fins. The stomach contained a few pieces of eel grass (*Zostera*) and a few ounces of a clear, yellow, oily fluid. The weight was estimated to be between 40 and 45 kg.

Cetorhinus maximus (Gunnerus), basking shark. Bigelow and Schroeder (1948, *Fishes of the western North Atlantic, 1:154–5*) say: "In colonial days the southern and western parts of the Gulf of Marine appear to have supported a considerable population ... But the local stock soon went ... into the try pot". These authorities can cite only 16 records (a few records involve more than one specimen) for this species from waters north of Cape Cod during the period from 1840 to the writing of their book. Some recent observations seem to temper this melancholy history and suggest a healthy population of this species in New England waters. At Cape Porpoise, Maine this animal is regarded as common enough by the fisherman there and is known as "nurse fish". In the spring months the mackerel-netters working out of this harbor commonly carry a saw which is used to untail such nurse fish and other large sharks (presumably mostly or wholly *Lamna*) as become entangled in their nets. A 20-footer was thus dispatched by fishermen about 10 miles southeast of Cape Porpoise on June 1, 1958. Another of this size was seen by W. E. Schevill and myself on the previous day a few miles northeast of Cape Porpoise. In the same area as the latter, two specimens between 15 and 20 feet in length were seen by Schevill on June 3, 1958. On June 5, 1958, we harpooned one of the same size here but lost him at the end of an hour. The animals seen by us were all swimming slowly at the surface with parts of the dorsal fin or dorsal and caudal fins showing and were feeding (mouth open and buccal region greatly expanded). They are easy to approach as other authors have noted. The one struck immediately sounded and never again showed itself.

The R/V CRAWFORD encountered a basking shark, estimated at 30 feet in length, on June 26, 1959 off the coast of Nova Scotia in 44°24′N, 62°20′W and on June 27, 1959 reported about 30 of these animals up to 30 feet in length during an hour's steam near 42°15′N, 64°46′W. Two individuals were almost run down by the vessel.

On August 3, 1959, W. E. Schevill and R. G. Weeks spotted a specimen 20 to 25 feet long from the air over the southwest edge of Stellwagen Bank about 10 miles northwest of Provincetown, Mass. On August 30, 1956, W. E. Schevill threw a harpoon at an eight– to nine–foot specimen in Menemsha Bight, Martha's Vineyard, Mass.

Sphyrna lewini (Griffith), a hammerhead shark. (This is the animal called *S. diplana* Springer by Bigelow and Schroeder, 1948, *Fishes of the western North Atlantic, 1:415*. According to Fraser-Brunner, 1950, *Rec. Austral. Mus., 22:213–4, S. diplana* must be regarded as a synonym of *S. lewini*, a possibility suggested by Bigelow and Schroeder). Since the Atlantic distribution of this shark is poorly known, the species having been confused with *S. zygaena* for many years, the following record is of interest.

A female, 304 cm. in total length (214 cm. from snout to anterior margin of precaudal pit), was harpooned on July 26, 1959, from the R/V BEAR at 37°55′N, 73°55′W. The animal was swimming at the surface with parts of the dorsal and caudal fins showing. The upper parts are a warm, olive-drab color as seen underwater. The fish was easily approached and struck but after a 10-minute struggle the harpoon-head withdrew. The shark surfaced nearby and was struck again and shot and landed after 25 minutes more fight. The stomach of this specimen contained unidentified fish remains and cephalopod beaks. Some of the latter, judging from their size, belonged to animals 50 to 75 cm. long. About two liters of eggs (up to about 40 mm. in size) were present in one ovary. The stretched

oviducts and their supporting mesenteries suggested that this animal had previously borne young. The flesh of this animal is deep orange-red in color. A raw sample taken from the nape was very bland in taste and so soft as to be easily macerated by squeezing it between the tongue and the roof of the mouth.

On 25 July 1959, in 37°50′N, 73°50′W, a hammerhead shark of about the same size and appearance was seen. It was likely this species. This specimen sounded at the approach of the vessel, resurfaced, was approached a second time, sounded again and was seen no more.

On 30 July 1959, in 39°50′N, 70°50′W, two hammerheads swimming close together were seen which, judging from head and dorsal fin shape as well as general appearance, seemed to be this species. One was about 10 to 11 feet, the other about seven to eight feet long. These were approached numerous times. They sounded when disturbed but quickly reappeared at the surface. When swimming undisturbedly at the surface, the tail strokes were about one cycle per three seconds and about 75 cm. in amplitude.

Isistius brasiliensis (Quoy and Gaimard). Previous western Atlantic records are three: off Rio de Janeiro, from among the Bahamas and 160 miles north of the Bahamas (Bigelow and Schroeder, 1948, *Fishes of the western North Atlantic, 1:512*). A female specimen about 16.5 cm. in total length was taken at night in an Isaacs-Kidd midwater trawl between the surface and 415 meters on March 4, 1954, within a few miles of 19°N, 66°W. When removed from the net this specimen showed no signs of the brilliant luminescence for which the species is noted; however, the animal was near death.

Squatina dumerili (LeSueur), angel shark. Massachusetts records where summarized by Backus (Copeia, *1957:248*). Additional records are given which suggests that this animal is more common in southern New England waters than previously supposed.

A male specimen, 109 cm. in total length, was trawled in 60 meters off Race Point, Provincetown, Mass., sometime during the first week of December 1957 by Captain Norbert Macara of Provincetown.

A male specimen about 110 cm. in total length was trawled in 120 meters of water at about 40°10′N, 70°05′W on February 1 or 2, 1957, by the vessel R. W. GRIFFIN.

A specimen, about 115 cm. in total length, was trawled in Menemsha Bight, Martha's Vineyard, Mass. sometime between August 15 and 20, 1959.

Attention is called to the photograph of a specimen published in the *New Bedford Standard-Times* on October 24, 1957. The animal was trawled in 48 meters of water about 25 miles southeast of Noman's Land, Mass.

The following records were kindly furnished by Mr. William C. Schroeder:

A male, 112 cm. long, was taken in 133 meters of water at 39°55′N, 71°45′W by the dragger PRINCESS on March 21, 1957.

The dragger GROWLER caught a "large one" near Veatch Canyon (about 40°N, 69°30′W) in 125 meters of water on March 27, 1957.

A dragger took a male about 110 cm. long in Menemsha Bight, Martha's Vineyard, Mass. on August 15, 1957.—RICHARD H. BACKUS, *Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.*

SYNOPSIS OF THE LAMPRIDIFORM SUBORDER VELIFEROIDEI.—Two specimens of a Hawaiian veliferid which were recently received from William A. Gosline constitute the first record of their suborder from the Eastern Pacific. They fit the descriptions of two nominal species and represent, in my opinion, a hitherto unrecognized second genus of the Veliferidae. These two, together with a specimen from Japan which was generously loaned to me by the British Museum (Natural History), form the basis of the synopsis and the diagnoses which follow:

Suborder Veliferoidei

Diagnosis.—A chamber lies between the orbits, its floor containing the mesethmoid and orbitosphenoid, its roof formed by the frontals, and receiving the ascending processes of the premaxillae and maxillae when the jaw is retracted. The rostral cartilage acts as a lubricated bearing in the protraction and retraction of the upper jaw. The epiotics are separated by the supraoccipital. The suborbital series is complete. Strong ribs are attached to the parapophyses. The pelvic bones are imbedded in ligament between the coracoids and do not articulate with these bones. The posttemporal is forked. The pectoral fin-rays are inserted on the scapula and four radials; three radials contact the scapula and one contacts the coracoid. The coracoid is normal in size and shape, tapering ventrad. Branched, segmented rays are present in all fins. The dorsal and anal fins have scaly sheaths at their bases. There are no spines at the bases of the fin-rays. All rays are smooth. The anal fin is large. The caudal fin is forked and symmetrical and of normal teleostean appearance. The swimbladder is physoclistic. There are 33–34 vertebrae, 6 branchiostegal rays and 8–9 pelvic fin-rays. One family.

Family Veliferidae

Diagnosis.—The nostrils are paired. The frontals and supraoccipital together form a cranial crest which is much larger than the rest of the skull. The swimbladder extends far beyond the anus; its drumming muscles and polyhymnic tendon are attached to the first haemal spine. The pelvic fins have scaly axillary processes. No teeth. The body is covered with deciduous imbricate cycloid scales. The body form is deep and compressed. Two genera.

Velifer Bleeker (*Verhandl. Kon. Akad. Wetten. Amsterdam, 18:16,* 1879, "Japan"). (*Velifer* Schlegel, *Faun. Japon., Poiss., p. 312, Suppl. Pl. A*, 1850, non-binomial.)

Genotype: Velifer hypselopterus Bleeker (*loc. cit.*)

Diagnosis: The preorbital is moderate, without a notch to accomodate the mandible. When the upper jaw is fully retracted the maxillae are only partially hidden beneath the preorbitals. The preorbital meets the nasal anterior to the olefactory sac on a level with the top of the eye. The frontals join to form the cranial crest above the nostrils. A bony crest runs forward on the cranial crest surface of the frontal. The maxilla ends beneath the anterior edge of the eye; its blade is markedly broadened caudad. The articular is triangular, tapering toward the angle of the jaws. The ascending limb of the preopercular pore canal is perpendicular to the horizontal limb. The dorsal fin has two spinous rays, the anal fin has one spinous ray. The entire dorsal fin has a scaly sheath. The dorsal and anal enlarged sheath scales are much deeper than long, each with a backward-directed process near its distal border. The pelvic axillary process is long and free from the body. A single species.

Velifer hypselopterus Bleeker

Material seen.—British Museum (Natural History) No. 1849.10.9.16, a partially eviscerated Japanese specimen 165 mm. in standard length.

D.—2 spinous, 21–24 simple, 8–10 branched, total 32–36; A.—1 spinous, 15–16 simple, 8–11 branched, total 25–27; P_1.—1 simple, 14–15 branched; P_2.—1 simple, 7 branched; gillrakers—4 + 11–12; l.l.—about 70–72; vertebrae—16 + 17 = 33.

Useful descriptions of the species were given by Regan (*Proc. Zool. Soc. London: 633–4,* 1907; *ibid.: 634–43,* 1907; *Proc. Roy. Soc. London, ser. B, 96:193–207,* 1924), Gregory (*Trans. Amer. Philos. Soc. 23, (2):viii + 75–481,* 1933), and Smith (*Ann. Mag. Nat. Hist., ser. 12, 4:497–509,* 1951). The otoliths were described by Frost (*Ann. Mag. Nat. Hist., ser. 9, 19:439–45,* 1927) and the swimbladder by Walters (Copeia, 144–145, 1960).

The Japanese specimen has 4 + 12 gillrakers, no different from the South African counts as given by Smith. It has 6 branchiostegal rays, the same as reported by Regan. Smith counted 4 branchiostegal rays in two South African specimens but these counts should be verified since they are abnormally low for a lampridiform fish. Smith reported the absence of pyloric caeca, and the Japanese specimen can furnish no information in this matter. Here again Smith's material should be reexamined since all other members of the order have numerous slender pyloric caeca. Smith identified a "supramaxilla" in this and the following species. My observations confirm his description of the location and action of this structure, but the "supramaxilla" is really the rostral cartilage which is commonly found in fishes having protractile mouths. No member of the Lampridiformes is known to have a supramaxilla. Smith characterized the Veliferidae as not having scales on the fins. The Japanese specimen shows no evidence of scales, but *Velifer multiradiatus* has many cycloid scales on its caudal fin.

Metavelifer, *gen. nov.*

Genotype.—*Velifer multiradiatus* Regan (*loc. cit.* 1907, "north-west coast of Australia.")

Diagnosis.—The preorbital is large, with a notch to accomodate the articular portion of the mandible. When the upper jaw is fully retracted the maxillae are entirely hidden beneath the preorbitals. The preorbital meets the nasal anterior to the olfactory sac on a level with the middle of the eye. The frontals join to form the cranial crest behind the nostrils and almost in line with the anterior edge of the orbit. A bony canal runs forward on the orbital surface of the frontal. The maxilla ends well before the eye; its blade is not markedly broadened caudad. The articular is robust and rectangular, and does not taper toward the angle of the jaws. The ascending limb of the preopercular pore canal forms an obtuse angle with the horizontal limb. The dorsal fin has 21 or 22 spinous rays and the anal fin has 17 or 18 spinous rays. The last 16 to 18 dorsal rays do not have a sheath at their bases. The enlarged dorsal and anal sheath scales are ovate and lack a backward-directed process near their distal borders. The pelvic axillary process is short and not free of the body.

"Metavelifer" means "after *Velifer*," assuming the new genus is more specialized than *Velifer*. A single species is known.

Metavelifer multiradiatus (Regan)

Synonym.—*Velifer multispinosus* Smith (*loc. cit.*, "not far from Lourenço Marques," Mozambique.)

Material seen.—University of Hawaii No. 2343, two specimens 146 mm. and 189 mm. in standard length, the larger one now American Museum of Natural History No. 20405; caught by trap in about 100 feet of water off the Waianae Coast of Oahu, Hawaii in 1955 and 1956.

D.—21–22 spinous, 20–23 branched, total 41–44; A.—17–18 spinous, 16–19 branched, total 33–36; P_1.—1 simple, 14–15 branched; P_2.—1 simple, 8 branched; gillrakers—3 + 9–10; l.l.—about 40–42; vertebrae—16 + 18 = 34.

Smith regarded the spinous rays of his 210 mm. (total length) South African specimen of *V. multispinosus* as true spines, not merely bony rays; the fourth through sixth dorsal rays were broken. On the other hand, Regan (*loc. cit.*) did not specifically comment on the anterior dorsal and anal elements of *V. multiradiatus* and it is inferred his badly preserved Australian specimen of 55 mm. total length had segmented simple rays rather than spines. McCulloch (*Zool. Res. "Endeavor"* 1909–10, *2(3):111–2*, 1914) had three more Australian specimens, 96–117 mm. from preorbital to middle caudal rays; he said the anal has one spine, the rest of its elements being rays, and the first five dorsal elements may be true spines but the sixth and those following are simple rays. It is not unusual for rays to transform into spines, this being known for example in the anal fin of *Roccus saxatilis* (Mansueti, *Contrib. Chesapeake Biol. Lab. no. 113:1–12*, 1958) although such transformations generally take place at small body sizes. Smith was aware that the simple rays might transform into spines, but doubted this because McCulloch's material was presumably beyond the juvenile stage. In both Hawaiian specimens, 184 and 242 mm. in total length, the extremely long sixth dorsal spinous ray exhibits true segmentation but the other spinous rays seem segmented only under certain kinds of illumination. These pseudosegmentations appear to be branchings of the canal within each spinous ray, and they are not regular in distribution. McCulloch may have interpreted the canal branchings to be segmentations if his fishes had spinous rays, but it is conceivable that he saw true segmentations and that these disappear with age.

The Hawaiian fishes agree well with the descriptions and illustrations given by Regan, McCulloch, and Smith. They have the same numbers of scales, fin-rays, gillrakers and vertebrae as given by one or two or all three authors. They have the dark blotch on the body at the origin of the branched dorsal fin-rays as reported by all three authors, they have the very unusual squamation which Smith described, they have scales on the caudal fin as reported by McCulloch, and the lateral line is of the same form as that reported by both McCulloch and Smith. There is no doubt in my mind that Regan, McCulloch and Smith had the same species and that this is identical with the Hawaiian material.

The swimbladder of the larger Hawaiian specimen compares well with Smith's drawing of the South African fish. The drumming muscles and polyhymic tendon are the same as those of *Velifer* but the anterior chamber is ellipsoidal instead of subtriangular as in *Velifer* (cf. Walters, *loc. cit.*).

There are some slight differences between Smith's account of *V. multispinosus* and the Hawaiian material, and these differences are probably not significant. In the Hawaiian fishes the maximal body depth is at the anal origin, and in *V. multispinosus* it is said to be at the pelvic origin. However in Smith's drawing, radiograph and retouched photograph of *V. multispinosus* the indicated maximal depth is at the anal origin. Smith reported that pyloric caeca were absent, the stomach long, and the intestine short in *V. multispinosus*. The radiograph indicates that the visceral mass is similar to that of the Hawaiian fishes. In these the stomach is short but U-shaped and without evident gastric caecum but with a mass of small slender pyloric caeca, and the long intestine is looped three times. Perhaps Smith did not dissect the digestive tract free to trace it out in *V. multispinosus*. At first the Hawaiian fishes were found to have four branchiostegal rays, as given for *V. multispinosus*. Closer examination disclosed six branchiostegal rays, placed very close together, in both Hawaiian specimens.—VLADIMIR WALTERS *The American Museum of Natural History, New York 24, N. Y.*

RAINBOW TROUTS, *SALMO GAIRDNERI*, WITH ANOMALOUS CAUDAL AND PELVIC FINS.—The object of this note is to describe in *Salmo gairdneri*, an unusual caudal fin in the "steelhead" stage, and three pelvic fins in two wild rainbow trout. Steelhead is the term applied to those of the species which descend to the sea or large lakes and return to streams to spawn.

In April, 1959 while trapping the downstream

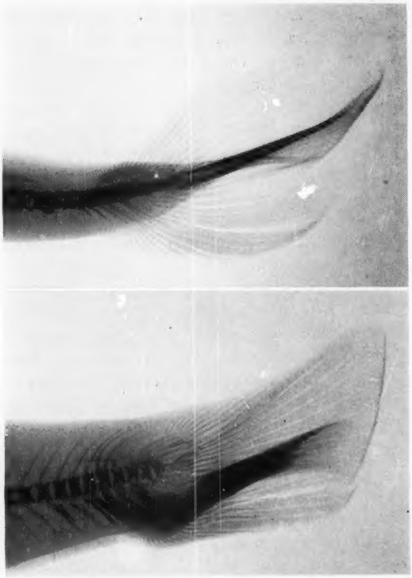

Fig. 1.—Dorsal (top) and side view x-rays of the caudal fin anomaly of a rainbow trout, *Salmo gairdneri*.

migration of salmon and steelhead trout in the Yakima River, Washington, the author observed a young steelhead with an unusual caudal fin. The specimen was in its second year of life and following preservation in formalin measured 181 mm. in total length. The normally positioned vertical caudal fin lacked a ventral lobe. In its place was a fin extending from the ventral side of the caudal peduncle on a horizontal plane and joined to the vertical portion of the caudal fin. In appearence the caudal fin was much like an airplane tail with its horizontal stabilizers. Dorsal and side view X-rays illustrate the specimen (Fig. 1).

The unusual occurrence of three pelvic fins in each of two wild rainbow trout was noted among fish taken with rod and reel from the White River, Chelan County, Washington, during July, 1959. While cleaning five trout the author noticed two fish, 7.5 and 8 inches in total length, with the anomaly. In both instances the third fin was located between the normally positioned pelvic fins. Except for being slightly shorter in length the third pelvic fin appeared normal. Maxfield (Copeia 1959(*3*):*232*) observed this same phenomenon on a hatchery-reared rainbow trout.—Robert R. French, *U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Seattle, Washington.*

RELATIONSHIP BETWEEN NUMBER OF PYLORIC CAECA AND LENGTH OF JUVENILE RAINBOW TROUT.—The number of pyloric caeca, while used as a character for distinguishing between species of some salmonids (Morton and Miller, Copeia (*2*):*116–24,* 1954), also has been employed in the separation of different stocks of a single species (McGregor, *California Fish and Game 9* (*4*):*138–50,* 1923). Use of morphological and meristic characters for racial distinction may involve comparison between samples of young individuals from known stocks and samples of adults whose origin is not certain. In these comparisons it is of importance to determine the extent of variation in morphological characters with age or length.

During the course of a study on populations of rainbow trout, *Salmo gairdneri,* spawning in outlet and inlet streams of Loon Lake, British Columbia (Lindsey, Northcote and Hartman, *Jour. Fish. Res. Bd. Canada 16*(*5*)*:695–719,* 1959) series of pyloric caecal counts were made both on samples of juvenile trout originating from the streams and of adult spawners entering these streams. At Loon inlet Creek, where the majority of young trout enter the lake early in their first summer, caecal counts, of necessity, were made on small individuals. The relationship between fork length and pyloric caecal count was examined over the size range of fry (young of the year) available.

Samples of fry and adult spawners were collected from Loon inlet Creek in the summer of 1953 and preserved in a 10 percent formalin solution. For fry, the section of gut bearing pyloric caeca was dissected out and counts made by removing caeca one at a time from the gut tube with fine-pointed forceps under a binocular microscope. Counts of pyloric caeca for adults were made with the naked eye by removing caeca from the gut tube. A small protuberance whose length was less than its diameter was not counted as a caecum.

Pyloric caecal counts for 304 fry are given in Fig. 1. Caecal counts increase rapidly in fry between 21 and 30 mm. in length, but show little further increase in larger individuals. Caecal counts of 86 adult trout taken from the 1953 Loon inlet Creek spawning run cover approximately the same range as those shown for fry of 40–55 mm. in length. Adult trout spawning in Loon inlet Creek varied between 130 and 370 mm. in length.

Relationship between number of pyloric caeca and body length has been examined in several species of salmonids. Vladykov (*Jour. Fish. Res. Bd. Canada 11*(*6*)*:904–32,* 1954) presents some data suggesting that individuals of *Salvelinus*

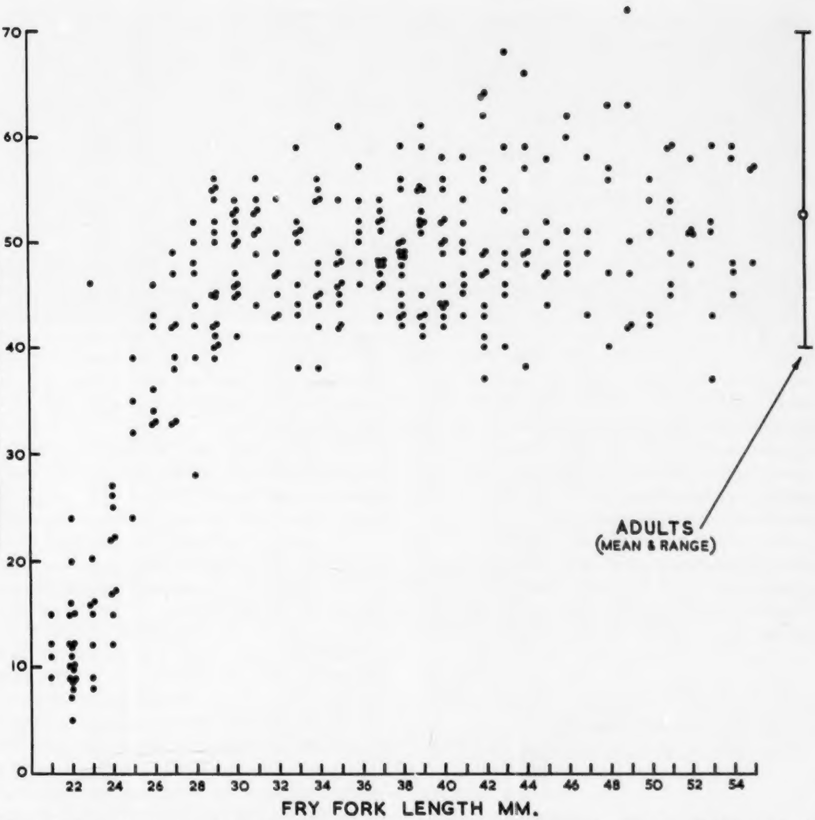

Fig. 1.—Relationship between number of pyloric caeca and length of 304 rainbow trout fry from Loon Lake inlet Creek, 1953. Mean and range in pyloric caecal count also given for 86 adult trout from spawning run to Loon inlet Creek, 1953.

aureolus less than 36 cm. in length had fewer caeca than larger individuals. Likewise larger specimens of *Salmo salar* in his data showed slightly higher caecal counts than did smaller individuals; however, samples were small and collected from different areas. J. D. McPhail (*M. Sc. Thesis, University of British Columbia,* 1959) compared the relationship between fork length and pyloric caeca in *Salvelinus alpinus* and *S. malma*. No significant correlation was evident between number of pyloric caeca and length of *S. alpinus* from Fraser Lake, and Karluk Lake, Alaska. In each case individuals ranged between about 100 and 400 mm. in fork length and included well over 30 fish per sample. Likewise in a sample of 30 specimens of *S. malma,* from Karluk Lake ranging between 80 and 190 mm. in fork length, no significant correlation was found between length and caecal count. However, McPhail reports (personal communication) that examination of a few smaller individuals of *S. malma* suggests a decline in caecal number at lengths less than 80 mm. Vernon (*Jour. Fish. Res. Bd. Canada 14(4):573–98,* 1957) within three areas of Kootenay Lake, B. C., could find no correlation between caecal count of kokanee and either weight or fork length of individuals in the size range studied (160–280 mm.).

Apparently there is little conclusive evidence in the literature of number of pyloric caeca being correlated with length of fish, however, most studies dealing with caecal counts have only treated larger juveniles or adult individuals. In the case of rainbow trout fry, it is evident (Fig. 1) that for comparative purposes caecal counts preferably should be made on individuals larger than 40 mm. A correlation be-

tween body length and number of pyloric caeca may well occur in young of other species. The possibility of such a relationship should be considered when caecal counts are used for racial distinction between juvenile fish.—T. G. NORTHCOTE, *Institute of Fisheries, University of British Columbia, Vancouver, B. C., Canada and* R. J. PATERSON, *Fish and Wildlife Division, Department of Lands and Forests, Edmonton, Alberta, Canada.*

A SIMPLE CLAMP TO AID IN COUNTING FIN RAYS.—Counting fin rays in a well preserved fish is a relatively easy procedure. Counting fin rays in poorly preserved fishes with depressed or folded fins with stiff interradial membranes is often a difficult task. In these specimens both hands are needed to spread the fin for counting, making it difficult to hold the fish and to count off the rays. The clamp discussed here is designed to hold the fin in the spread position, freeing the hands and enabling easier and more accurate counts.

Two models of the fin clamp have been constructed and found satisfactory. The first model is made by cutting part of the jaws and tips off a wooden springtype clothespin (Fig. 1A). This results in a smaller clamp usable on small fishes. Slender needles about 1½ inches long are then broken in half. The sharp-ended half is kept and its broken end forced into the clothespin with a pair of pliers. The needles are angled toward the jaws and inserted parallel to the gape of the jaws as in Fig. 1B. Either one or two needles may be used per clamp.

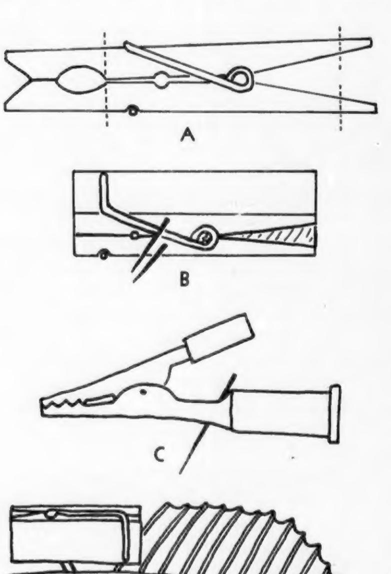

Fig. 1.—A—Wooden springtype clothespin with dashed lines showing where to cut. B—completed fin clamp showing where needles are inserted. C—modified "alligator" fin calmp. D—fin clamp in use.

Another, perhaps more elegant, model of the fin clamp can be made from an electrical "alligator" clamp. The needle is wedged in the wire hole on the long arm of the clamp (Fig 1C). The springs in these clamps are quite strong which makes them suitable for large fishes.

The fin clamp is used by fastening the jaws onto the front edge of the fin, pulling the fin forward (causing it to fan out) and then sticking the needles into the body of the fish, so as to hold the fin open. The clamp is shown in use in Fig. 1D.

The clamp may also be used for spreading the pectoral fin or holding the mouth open to examine teeth on the roof of the mouth. For these purpose it is necessary to insert the needles in the clamp perpendicular to the gape of the jaws (as in the "alligator" fin clamp Fig. 1C).—D. E. MCALLISTER, *Curator of Fishes, National Museum of Canada, Ottawa.*

VARIATION, DISTRIBUTION, AND ECOLOGY OF *ANCHOVIELLA ANALIS*, AN ENGRAULID FISH FROM THE PACIFIC SLOPE OF MEXICO.—The original description of this species (Miller, *Jour. Wash. Acad. Sci., 35(8):266–67, fig. 1,* 1945) was based on four faded specimens, all somewhat shrivelled, collected in 1893. Between 1939 and 1959, nine additional examples were seined, and two others, evidently secured in 1889, were discovered at Stanford University. A redescription of the species, based on the 15 specimens now available (including reexamination of the types), affords a better idea of its variation and distribution and confirms its validity. A photograph of a recently collected specimen (Fig. 1) well portrays the distinctive combination of characters of this rarely obtained fish—particularly the position and length of the anal fin, length of the maxillary, position of the pelvic fins, and pigmentation. Notes on the ecology of the species are also included.

In the description that follows, the method of presentation is essentially that used in the original description; vertebral counts, including the urostylar vertebra, were obtained from radiographs. Principal dorsal and anal rays are obtained by subtracting 2 from the total ray count. Total dorsal rays 12 (7), 13 (8); total anal rays 31 (3), 32 (1), 33 (3), 34 (5), 35 (3); pectoral

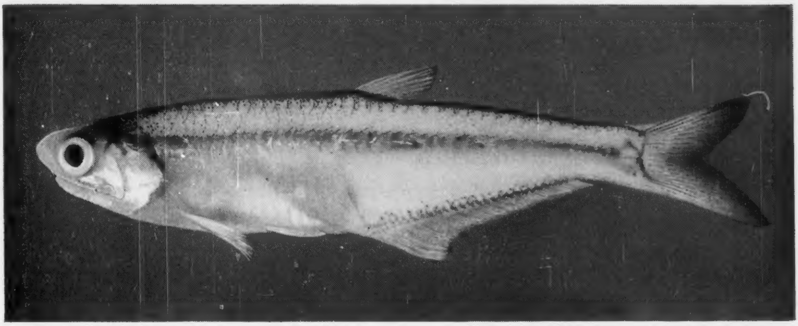

Fig. 1.—Adult of *Anchoviella analis* (UMMZ 177265), 72 mm. S.L., from Laguna de Puerto del Río, Nayarit; slightly retouched.

rays (both fins counted) 12 (14), 13 (16); pelvic rays almost invariably 7 in each fin (rarely 6 on one side); principal caudal rays 19. Scales in lateral series approximately 37 to 40. Vertebrae 39 (7), 40 (8). Gill rakers 17 to 20 on upper limb, 22 to 25 on lower limb, total number 39 (1), 40 (1), 41 (2), 42 (6), 43 (3), 44 (2).

In standard length (51–94 mm.): head 3.8–4.3; body depth 3.9–4.5; anal base 2.55–2.75; pectoral fin 4.9–5.5; postorbital 7.3–7.7 (excluding types); mandible 6.65–7.4. In head length: eye 3.2–3.5; snout 5.0–5.5; maxillary 1.6–1.8; mandible 1.6–1.8; pectoral 1.2–1.3; pelvic 2.3–2.65; depressed dorsal fin 1.3–1.5; dorsal fin base 2.5–3.1; axillary scale of pectoral 2.5–3.35.

Pectoral length in anal base 1.8–2.1; eye in postorbital 1.6–1.8; body width in depth 2.8–3.8 (excluding the types).

Body comparatively deep and strongly compressed, the depth increasing in larger specimens. Maximum known size 94 mm. standard length. Ventral profile more curved than dorsal profile. Snout fairly short, bluntly pointed, projecting far beyond tip of mandible. Longest dorsal rays reach well beyond tip of last ray when fin is depressed. Dorsal origin equidistant between caudal base and some point between posterior margin of pupil and anterior rim of orbit, usually falling on pupil; origin of anal fin directly below to very slightly behind dorsal origin, equidistant between caudal base and some point on eye (usually on pupil); pelvic extending more than halfway to anal origin, inserted equidistant between pectoral base and anal origin or slightly nearer latter; pectoral long, reaching slightly to well beyond insertion of pelvic.

Silvery band on midside moderately developed, widest anteriorly, narrowing between dorsal and anal origins and narrowest on caudal peduncle; its ventral margin irregular and its greatest width about two-thirds to three-fourths eye diameter. Side of head silvery, with metallic bluish luster. Pigmentation (poorly retained on types and 1889 specimens) represented by an irregular, double row of melanophores at and near base of anal fin; a fine, median black line with a few larger melanophores on ventral surface of caudal peduncle; rows of dark pigment extending along caudal rays from the base of fin distally; an X-shaped pattern of deep-lying pigment at caudal base (similar to that in *Anchoa compressa*); scale pockets outlined by fine pigment lines above lateral stripe and mostly before dorsal fin; a dendritic pattern of black pigment underlying most of the lateral stripe, and overlain by scattered, coarse, lighter-colored melanophores; upper edge of opercle and of shoulder girdle coarsely pigmented; back with irregular, parallel rows of coarse and fine melanophores extending anteriorly onto top of head as two widely separated rows; these become concentrated into an hour-glass-shaped group of melanophores on snout, whereas posteriorly the two rows join shortly in advance of occiput; a few scattered melanophores about anterior and ventral margins of orbit on some; tips of mandibles occasionally with 1 or 2 large melanophores—otherwise ventral surface of head and all of abdomen immaculate. In some, the dorsal fin has a few pigment cells on anterior rays and along base; pectoral, pelvic, and anal fins immaculate.

Except for the two specimens at Stanford University (SU), all of the new material is deposited in the University of Michigan Museum of Zoology (UMMZ). SU 6842, 2 (79.5 and 94 mm. S.L.), presumably obtained by the *Albatross* on March 31 or April 1, 1889, at San Juan Lagoon, near the mouth of the Yaqui River, Sonora, México. These specimens were found in a jar, broken during the San Francisco earthquake

(1906), that also contained *Anchoa schultzi, A. compressa,* and an unidentified species of *Anchoa. Anchoa schultzi* and *Anchoviella analis* were alcohol-fixed, the other two formalin-fixed. The Stanford register gives the locality for 6842 as Panamá, but also states that this lot "Includes 13." Register 13 reads "*Stolephorus compressus.* San Juan Lagoon, Mex. Albatross. 1890. With 6842". Published records (1892, *Rept. U.S. Comm. Fish and Fish., 1888:442*; 1901, *ibid., 1900:407, sta. 3037*) show that the *Albatross* was at or off San Juan Lagoon on March 31 or April 1, 1889. San Juan Lagoon lies between Algodones and the Río Yaqui, apparently a little north of the mouth of the Yaqui; Boyd W. Walker informs me he has not yet (1959) been successful in finding this lagoon. Original labels in the jar state that the fish came from San Diego and San Juan Lagoon, but there is no mention of Panamá. It is most unlikely that the specimens of *A. analis* came from San Diego whereas the Mexican locality is within reason for the northern limit of the species, which unquestionably occurs as far north as the vicinity of Mazatlán (see below). Likewise, *Anchoa schultzi* is a species of the upper Gulf of California. UMMZ 173655, 2 (51, 55 mm.) from near the mouth of Rio del Presidio, just southeast of Mazatlán, Sinaloa; M. Castillo, July 5, 1939. UMMZ 172247, 6 (53–62 mm.) from a slough at the northern end of Laguna de Mexcaltitán (the type locality), Nayarit; R. R. Miller and John T. Greenbank, March 28, 1955. UMMZ 177265, 1 (72 mm.) from Laguna de Puerto del Rio at the ferry crossing between Tecuala and Novillero, Nayarit; R. R. Miller and R. J. Schultz, March 20, 1959.

These records indicate that the species is distributed near the coast along the Pacific coastal plain from west of Tuxpan, Nayarit, to near the mouth of the Río Yaqui, southern Sonora, a distance of more than 500 miles over a latitudinal range from about 22° N. nearly to 28° N. That the species apparently does not invade the sea is indicated by its absence from repeated collections made by Boyd W. Walker and students along the Gulf of California during the past decade.

Anchoviella analis clearly prefers brackish-water, inhabiting tidal lagoons and estuaries. Ecological conditions at the two Nayarit stations during the latter part (March) of the long dry season indicate that this anchovy inhabits somewhat murky to muddy brackish to salt waters, with bottoms of mud or of firm sand overlain by a veneer of mud. Vegetation was absent and the immediate shore varied from mangrove border and muddy banks to sandy beach; beyond lay marshes, swamps or flat pastureland that was originally tropical savannah (Leopold, *Ecology, 31(4):515, fig. 1,* 1950). The current was slight or none but varies according to tidal movements. The temperature at Mexcaltitán was 77° F. (air 78° F.) on March 28, 1955, and at Puerto del Rio it was 82° F. (air 84° F.) on March 20, 1959. The maximum depth of capture varied from 3 to 5 feet; the gear employed was a 15-foot ¼-inch mesh tied seine and a 30-foot tied bag seine (⅜ inch mesh on wings, ¼ inch in bag). The 1959 station is on the western edge of the Marismas Nacionales (National Swamps), which extend for about 60 miles along the coasts of Nayarit and southern Sinaloa.

Species commonly associated with *A. analis* are those fishes characteristic of the brackish-water community of the region, such as anchovies, poeciliids, robalos (*Centropomus*), mullets, gerrids, gobies, and flatfishes. There were 6 species of gobies (2 eleotrids and 4 gobiids, comprising 5 genera) and 6 species of anchovies (2 genera) taken with *A. analis*; the latter inlcuded *Anchoa curta, A. exigua, A. lucida, A. mundeoloides, A. naso,* and *Anchovia macrolepidota.* Although *A. naso* was listed by Hildebrand (*Bull. Bingham Oceanogr. Coll., 8:102,* 1943) only from Panamá to Perú, it has recently been found as far north as San Juanico Bay, Baja California (Peterson, *Inter-Amer. Trop. Tuna Comm., 1:170,* 1956).

The relative abundance of *Anchoviella analis* among the five species of anchovies taken at the 1959 station (Laguna de Puerto del Río) is indicated by the following numbers: *Anchoa curta,* 113 juveniles; *A. exigua,* 3 juveniles; *A. mundeoloides,* 138 juveniles; *A. naso,* 1 juvenile; and *Anchoviella analis,* 1 adult.

Anchoviella analis appears to be without a close relative among the described species of this genus, as indicated in the original description. The new material does not cast further light on its immediate relationships but again stresses a resemblance to certain species of *Anchoa*—e.g., *A. panamensis* and *A. compressa.* The Mexican species differs strikingly from those two species (comparison based on fresh material from Nayarit and California) in the much shorter maxillary (1.6–1.8 versus 1.1–1.4 in head length) and mandible (1.6–1.8 versus 1.25–1.4). It has fewer gill rakers than *Anchoa compressa* (44–47) and more than *A. panamensis* (35–38), with which it is virtually sympatric.

The field work that made this paper possible was supported in 1955 by a grant from the Horace H. Rackham School of Graduate Studies, University of Michigan, and in 1959 by a grant (NSF G-4854) from the National Science Foundation. The Mexican Government kindly provided a collecting permit. Margaret H. Storey located and loaned the two Stanford specimens

through a lead from Boyd W. Walker, who also made available fresh material of *Anchoa*. Leonard P. Schultz placed the type material at my disposal. John T. Greenbank and R. Jack Schultz assisted ably with the collecting. The photograph was made by William L. Brudon.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

ICHTHYOLOGICAL TYPE SPECIMENS EXTANT FROM THE OLD ILLINOIS STATE LABORATORY OF NATURAL HISTORY.—Of the several fishes described from Illinois waters by Stephen A. Forbes, Edward W. Nelson, David Starr Jordan, and others associated with the old Illinois State Laboratory, the types of 11 nominal species have been inherited by the Laboratory's offspring agency, the Illinois Natural History Survey. The types of several other species described from Illinois were evidently deposited elsewhere, or they have been lost in the half-century since the intensive investigations directed by Forbes. A few of those extant have been studied by competent ichthyologists in recent years; others have received little attention and their existence may not be known to students of ichthyology. The following notes on the material in the Illinois Natural History Survey collections will announce the availability of these types. All of the specimens are in poor condition.

Parascaphirhynchus albus Forbes and Richardson, *Bull. Illinois State Lab. Nat. Hist. 7:38,* 1904 (Mississippi River at Grafton, Jersey Co., Illinois) [*Scaphirhynchus album* (Forbes and Richardson)]. The description was drawn from nine specimens, five of which are extant. The syntypes (three entire specimens and two heads only) have turned green from the copper container in which they were stored for so many years and they are somewhat desiccated.

Alburnops nubilus Forbes, *in* Jordan, *Bull. Illinois State Lab. Nat. Hist. 1:56,* 1878 (Rock River, Ogle Co., Illinois) [*Dionda nubila* (Forbes)]. Of the 20 specimens available to Forbes, six are extant. The collecting data indicated in the accession catalog are Rock River, Oregon, Ogle Co., Illinois, May 6, 1877.

Episema jejuna Forbes, *in* Jordan, *Bull. Illinois State Lab. Nat. Hist. 1:60,* 1878 (Illinois River) [*Notropis blennius jejunus* (Forbes)]. Of the "number of specimens" available at the time of the description, two small series, both labeled types, have been found. Two specimens from the Illinois River, Pekin, Tazewell Co., Illinois, June 2, 1880, and 16 specimens from the Illinois River, Henry, Marshall Co., Illinois, Nov. 1, 1877, presumably stand as cotypes, although the discrepancy between date of publication of the description (1878) and that listed in the accession catalog for the Pekin collection (1880) should be noted.

Notropis anogenus Forbes, *Bull. Illinois State Lab. Nat. Hist. 2:138,* 1885 (Fox River at McHenry, Illinois). Of the 24 specimens from which the description was drawn, eight syntypes are extant. Bailey (COPEIA *1959 (2):120,* 1959) has recently designated one of these as lectotype and pointed out that two of the eight are *Notropis heterodon* (Cope). Data in the accession catalog for the series are Fox River, McHenry, McHenry Co., Illinois, May 8–10, 1880.

Oxygenum pulverulentum Forbes, *Bull. Illinois State Lab. Nat. Hist. 2:136,* 1885 (Illinois River) [*Campostoma anomalum pullum* × *Chrosomus erythrogaster* hybrid according to Hubbs and Bailey (*Papers Michigan Acad. Sci., Arts and Letters 37:143,* 1952)]. The accession catalog contains the following data for the holotype and only known specimen: Illinois River, Peoria, Peoria Co., Illinois, June 1878.

Platygobio pallidus Forbes, *in* Jordan and Gilbert, *Synopsis, p. 220,* 1883 (Ohio River at Cairo, Illinois) [presumably a synonym of *Hybopsis gracilis* (Richardson), although the damaged holotype should be restudied by the person who revises this group of chubs]. Complete collecting data as listed in the accession catalog are Ohio River, Cairo, Alexander Co., Illinois, Sept. 23, 1879.

Sternotremia isolepis Nelson, *Bull. Illinois State Lab. Nat. Hist. 1:39,* 1876 (small weedy tributary to the Calumet River near Chicago, Illinois, and small streams in southern Illinois) [*Aphredoderus sayanus* (Gilliams)]. Three specimens, one of which bears a tag with the penciled notation "type," are extant, all listed in the accession catalog as being from Union County, Illinois, and collected in 1877. Attention is invited to the discrepancy between date of collecting and presumed date of publication of the original description.

Chologaster papilliferus Forbes, *Amer. Nat. 16:1,* 1882 (cave spring in Union Co., southern Illinois) [*Chologaster agassizi* Putnam]. Of the eight specimens cited by Forbes, three have been found, and one of these has a tag attached with the penciled notation "types." The collecting data in the accession catalog are Pine Hills, Union Co., Illinois, 1881.

Lepiopomus ischyrus Jordan and Nelson, *Bull. U. S. Nat. Mus. 10:25,* 1877 (Illinois River) [*Lepomis cyanellus* × *macrochira* hybrid according to Hubbs and Hubbs (*Papers Michigan Acad. Sci., Arts and Letters 15(1931):436,* 1932)]. One large, poorly preserved specimen bears a cloth tag with "type" printed in ink. The only information in the accession catalog is Illinois River.

Lepomis garmani Forbes, *Bull. Illinois State Lab. Nat. Hist. 2:135,* 1885 (Little Fox River at Phillipstown, Wabash River, and Drew Pond at Carmi, Illinois) [*Lepomis punctatus miniatus* Jordan]. Of the 15 specimens available to Forbes, five have been found. Data in the accession catalog are Little Fox River and Drew Pond, near Carmi, White Co., Illinois, Oct. 3, 1882, H. Garman.

Lepomis symmetricus Forbes, *in* Jordan and Gilbert, *Synopsis, pp. 473–4,* 1883 (Illinois River). Of the 15 original cotypes, eight are extant. The data in the accession catalog are Illinois River, Pekin, Tazewell Co., Illinois, Sept. 16, 1880.

A jar containing three lots of darters and a typewritten inner label stating "? types of *Boleosoma camurum* Forbes" deserves mention. The three collections are as follows: 1 specimen from the Ohio River, Cairo, Alexander Co., Illinois, Sept. 23, 1879; 6 specimens from Peoria Lake, Peoria Co., Illinois, Oct. 23, 1879; and 20 specimens from the Little Wabash River, Effingham, Effingham Co., Illinois, no date given. The specimens are in poor condition and most of them are so tiny that identification would be difficult. *Boleosoma camurum,* a synonym of *Etheostoma chlorosomum* (Hay), was described by Forbes *in* Jordan, *Bull. Illinois State Lab. Nat. Hist. 1:40,* 1878, from specimens taken in "Cache River and Clear Creek, Union Co.; Johnson Co.; and Pekin [Tazewell Co., Illinois]." There is no mention of Cairo, Peoria Lake, or Effingham in the original description, and there is no indication on the original labels or in the accession catalog that these specimens are types. Moreover, the typewritten inner label is obviously a relatively recent addition to the specimen jar. We feel confident that the new label is in error and that the types of *Boleosoma camurum* have been lost.—Philip W. Smith and David W. Bridges, *Illinois Natural History Survey, Urbana, Illinois.*

PARALICHTHYS SQUAMILENTUS JORDAN AND GILBERT FROM NORTH CAROLINA.—Ginsburg (*Fish. Bull. U.S. Fish and Wildlife Service, 52(71):333,* 1952) summarized the known range of *Paralichthys squamilentus* Jordan and Gilbert based on records from the waters of the Gulf of Mexico and Florida, and mentioned an unverified record from South Carolina. A northerly extension of the known range of *P. squamilentus* is provided by recent collections, of young and juvenile specimens, in the waters of North Carolina.

Since so few young *P. squamilentus* are available in collections, addenda to Ginsburg's descriptive notes seem warranted. Counts and measurements were made as outlined by Hubbs and Lagler (*Cranbrook Institute of Science, Bulletin 26:19–26,* 1958 revised). Fish were macerated in a two percent solution of potassium hydroxide, stained with alizarin red S and cleared in glycerin according to Evans (*Turtox News, 26(2): 42–47,* 1948) for the purpose of enumerating vertebrae and fin rays.

The material of *P. squamilentus* examined is as follows: captured in plankton tow, Beaufort Inlet—University of North Carolina (UNC) 2020, 2 spec. (13.5–14.5 mm. S.L.), 7 February 1958; captured with seine in surf at Atlantic Beach—UNC 2832, 1 spec. (128 mm. S.L.), 27 August 1957; UNC 2870, 17 spec. (20.5–32.5 mm. S.L.), 28 April 1958; UNC 2962, 6 spec. (25.5–32.5 mm. S.L.), 28 April 1959; UNC 2964, 3 spec. (15.0–23.0 mm. S.L.), 31 March 1959: and captured in trawl, approximately 34 04 N., 76° 15 W., 45–55 fathoms—UNC 3008, 1 spec. (209 mm. S.L.), 8 December 1959.

Young *P. squamilentus* are characteristically deep bodied. Standard length and depth (in parentheses) measurements in mm. of young *P. squamilentus* collected in North Carolina are as follows: 15.0 (8.5), 22.0 (11.0), 23.0 (11.5), 32.5 (18.0), 25.5 (13.5), 32.0 (17.5), 27.0 (14.5), 26.0 (14.0), 30.0 (17.0), 14.5 (8.5), 13.5 (7.5), 25.5 (13.0), 27.5 (14.0), 28.0 (14.0), 25.5 (13.0), 30.5 (15.5), 24.5 (12.5), 26.0 (13.5), 24.0 (13.0), 22.0 (11.0), 24.0 (13.0), 20.5 (10.0), 25.5 (13.0), 27.0 (14.5), 27.5 (14.0), 22.0 (12.0), 25.5 (13.5), 22.0 (12.5).

Table 1 contains enumerations of caudal vertebrae, dorsal and anal fin rays. One specimen had 11 precaudal vertebrate; all others counted had ten precaudal vertebrae. The dorsal and anal fin ray counts are similar to those counts made by Ginsburg (*op. cit. 52(71):273 and 275,* 1952) and Clark (*Quart. Jour. Fla. Acad. Sci. 21(2):187,* 1958). Dorsal and anal fin ray and vertebral counts are modally separable from enumerations made by Deubler (Copeia, *1958(2):113.*) on *P. albigutta, P. dentatus,* and *P. lethostigma.* Consideration of the relatively deep body and enumerative characters should permit ready diagnosis of young *P. squamilentus.*

Table 1

Meristic Data for Young *Paralichthys squamilentus* Collected in North Carolina in 1957, 1958, and 1959

Number of caudal vertebrae	27	28	29			
Number of specimens	9	16	1			
Number of dorsal rays	77	78	79	80	81	82
Number of specimens	4	3	8	6	2	3
Number of anal rays	60	61	62	63	64	
Number of specimens	1	7	16	1	1	

Young *P. squamilentus* may be found in inshore shallow waters as Ginsburg (*op. cit 52(71): 333–334,* 1952) tentatively concludes. It does not differ from *P. albigutta, P. dentatus* and *P. lethostigma* in this respect.

Four (22–24 mm. S.L.) of the specimens examined had recognizable stomach contents. Three contained teleostean remains which were approximately 12 mm. in total length and a fourth contained an unidentified crustacean.

Donation of specimens by Donald Dudley of the United States Fish and Wildlife Service at Beaufort, North Carolina is gratefully acknowledged.—BRIAN J. ROTHSCHILD, *Department of Conservation, Cornell University, Ithaca, New York,* AND EARL E. DEUBLER, JR., *University of North Carolina, Institute of Fisheries Research, Morehead City, North Carolina.*

STUDIES ON FISHES OF THE FAMILY CHARACIDAE.—NO. 17. *MORALESIA* FOWLER, THE PROPER GENERIC NAME FOR *ANACYRTUS TECTIFER* COPE.—In 1943 (*Bol. Mus. Hist. Nat. 'Javier Prado', año 7 (24 and 25):96*), Fowler established *Moralesia* for Cope's *Anacyrtus tectifer*. A year later, Kaszab (in *Español Coll, Eos [Rev. españ. entomol.], 20: 18,* 1944) used *Moralesia* for a new genus of tenebrionid beetles. Because *Moralesia* was 'occupied', though not 'preoccupied' ("Ocupa o gênero de Español, 1944 Coleoptera"—Travassos, *Dusenia, 3 (2):158* [p. 94 in the separate], 1952), Fowler for some reason decided that a new generic name was required for the fish and proposed the name *Moralesicus* (*Notulae Naturae, 310:9,* 1958). *Moralesicus* Fowler is an exact equivalent of *Moralesia* Fowler and should be added to the generic synonymy of the latter as given in Böhlke (*Proc. Acad. Nat. Sci. Philadelphia, 110:70,* 1958). The beetle genus was renamed *Moragacinella* by Español Coll (*Eos, 30: 162,* 1954).—JAMES E. BÖHLKE AND HAROLD J. GRANT, JR., *Academy of Natural Sciences, Nineteenth and Parkway, Philadelphia 3, Pa.*

CARAPUS HOMEI (RICHARDSON) IN A SEA CUCUMBER FROM THE MARSHALL ISLANDS.—Fierasferoid fishes living within holothurians and other aquatic hosts have for a long time attracted the attention of ichthyologists. Accounts of the typical tail-first entry of these fishes at the anus of the sea cucumber and some of the many variations of behavior have been reviewed in Arnold's systematic revision of the Carapidae (*Bull. Brit. Mus. (Nat. Hist.) Zool. 4(6):247–307,* 1956). *Carapus homei* was recorded from the Marshall Islands by de Beaufort and Chapman (*The Fishes of the Indo-Australian Archipelago.* Vol. 9, *484 pp,* 1951). In most records the host was not found or not identified.

Examination of several hundred sea cucumbers, chiefly *Holothuria atra,* in the Marshall Islands during a 10-year period for purposes of radioassay disclosed only this one occurrence of a contained fish. The host was a species of sea cucumber, *Stichopus chloronotus* Brandt, sampled only occasionally. Panning (*Mitt. Hamburg. Zool. Mus. 49:2–76,* 1944) lists for this dark green, almost black, holothurian, the expressive name "green prickly." The sea cucumber, 34 cm. in length, was found on September 13, 1959 in a shallow staghorn coral garden in Rongelap Lagoon near the northwestern portion of Kabelle Island. It was gently floated into a plastic bag to avoid discharge of adhesive strands, and frozen. In Seattle, it was thawed and opened dorsally with scissors, starting at the anus. The fish lay free, heading anteriorly in the posterior half of the body cavity (Fig. 1, upper) rather than being contained in any particular organ. It was removed, again photographed, x-radiographed, (Fig. 1, middle and lower) and preserved in formalin. Appropriate bodily measurements and meristic counts were derived from the x-radiographs, and the rest were obtained from the preserved fish.

Characteristics agree with descriptions of *Carapus homei* (Richardson) 1844. This species has been reported by Weber (*Siboga-Expeditie, 57:96,* 1913) from *Stichopus chloronotus* Brandt and *S. variegatus* Semper in the region of Borneo. Another known host species that is common in the Marshall Islands is *Actinopyga mauritiana* (Quoy and Gaimard) which was reported by Chopra (*Rec. Indian Mus. 33:303,* 1931) and by Mukerji (*ibid, 34:567–9,* 1932).

Table 1 gives for this specimen the measurements and meristic counts arranged for comparison with those given in Arnold's Table VI. Further nontabular description follows, with emphasis on the teeth to which Smith (*Ann. Mag. Nat. Hist. 8(90):401–16,* 1955) and others attribute taxonomic importance.

Maxillary free, extending past orbit; opercle ending at insertion of pectoral; pectoral pointed; first dorsal ray above eleventh vertebra; dorsal rays smaller than anal rays which start just behind anus at level of first vertebra; lower lip distinct; gill rakers about as long as filaments; teeth of upper jaw elongate, 0.3 mm. long by 0.12 mm. diameter at base, about 25 on either side flanked laterally by about twice as many angular, backwardly directed, incipient teeth covered by lip; one terminal canine anteriorly on either side of midline, 0.5 × 0.2 mm.; palatine teeth conical,

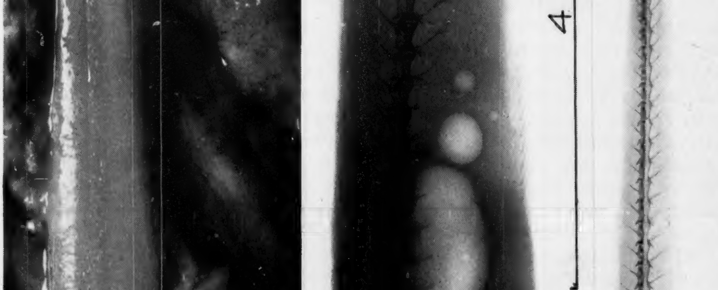

Fig. 1.—Upper; *Carapus homei* (Richardson) in posterior portion of body cavity of *Stichopus chloronotus* Brandt after freezing and thawing. Middle and lower: X-radiograph after removal from host. Light areas in abdominal region are artifacts caused by water between fish and film cassette.

0.2–0.4 × 0.2–0.3 mm., in two irregular rows, the larger teeth tending to be in the medial row, numbering about 17, and the outer row, numbering about 11, incomplete posteriorly; vomerine teeth six, conical, up to 0.8 × 0.5 mm., backwardly directed, in an irregular median row, flanked by small conical teeth. Teeth of lower jaw in irregular double row; outer teeth about 18 on a side, canine, comparable in size to upper terminal canines; inner teeth at least twice as numerous, conical, 0.2 × 0.2 mm.

Of particular interest is the relatively large size of the major otoliths (Fig. 1, middle) which is probably associated with the skillful maneuvering required of this commensal organism upon entering its host.

This specimen was deposited in the collection of fishes of the University of Washington, Number 14702.—KELSHAW BONHAM, *Laboratory of Radiation Biology, University of Washington, Seattle, Washington.*

TABLE 1

MEASUREMENTS AND COUNTS FOR *Carapus homei* FROM RONGELAP LAGOON AT KABELLE ISLAND, SEPTEMBER 13, 1959

	Absolute size, mm	Relative size	
		Percent of indicated length	Length considered
Total length	135		
Head length	18.2	13.5	Total
Head depth	9.5	52	Head
" width	7.5	41	"
Snout length	3.2	18	"
Eye, horizontal	3.9	21.5	"
Eye, vertical	3.2	18	"
Interorbital width	3.1	17	"
Maxilla, length	8.9	49	"
Pectoral fin	8.7	48	"
Body depth	11.4	63	"
Preanal length	15.4	11.4	Total
Pectoral insertion	18.2	13.5	"
First dorsal ray	32.2	24	"
Otolith 1 length	5.0	27.4	Head
" height	2.8	15.4	"
" thickness	1.0	5.5	"
Otolith 2 length	.58	3.2	"
" height	.3	1.6	"

Meristic characters	
Vertebral count 15 + 107 =	122
Dorsal ray "	155
Anal ray "	191
Pectoral rays, left	19
" " right	20
Branchiostegal rays, left or right	7
Gill rakers, left: 1 at angle; 2 below =	3
" " right: 1 at angle; 1 below =	2

NOTE ON SHARKS FROM RONGELAP ATOLL, MARSHALL ISLANDS.—The following observations during September 1959 on three species of sharks at Rongelap Atoll are recorded as a contribution to our understanding of the reproductive time-schedules of these sharks.

On September 3 a school of about 12 young black-tip sharks, *Carcharhinus melanopterus* (Quoy and Gaimard) was observed at low tide circling in 15 cm. of water just inside the east reef of Rongelap Island. Two of the smallest of these, a male 36 cm. and a female 33 cm. in total length with tail extended parallel to body, still had umbilical scars suggesting that a short interval had transpired since birth, probably not more than two months.

On the evening of September 3, in Rongelap Lagoon about 2 miles north of the west end of Rongelap Island, three female gray sharks, *Carcharhinus menisorrah* (Müller and Henle), were caught by Reid M. Kenady using rod and reel with grouper filet for bait, and brought aboard the ship by gaff. The two smaller sharks, 122 and 137 cm. in total length, contained neither embryos nor well developed ovarian eggs. The largest shark, 141 cm. long weighed 22 kg. and contained three embryos about 10 cm. long, one in the left and two in the right uterus. The embryos, attached yolk, and silvery membranes presumed to be shell material were preserved in formalin. This largest shark was slightly smaller than the smallest embryo-bearing specimen recorded by Schultz (*Fishes of the Marshall and Marianas Islands, Bull. U. S. Nat. Mus. 202:16,* 1953).

On September 19 while on watch at anchor in the lagoon off Gogan Island the boatswain of the "Aloto," Gerald F. Walker, fished with a shark line, catching first, gray sharks up to 120 cm. long. Then, using a 10-cm. chunk of the latter, he caught at 4:30 a.m. a female tiger shark, *Galeocerdo cuvier* (Lesueur). After four hours on deck the shark measured 268 cm. in total length with intact tail extended, and weighed 120 kg. Faint vertical markings appeared on the sides of the posterior part of the body, verified in photographs. Identification was assured by the shape of the teeth which were serrated on both inner and outer edges. Attached to the mouth was a dark green leech measuring about 5 x 1 cm. The beak, claw, and scute-remains of a sea turtle fell from the everted stomach of the shark as it was hoisted by the tail. Walker determined that no embryos were present.—KELSHAW BONHAM, *Laboratory of Radiation Biology, University of Washington, Seattle, Washington.*

A TECHNIQUE FOR AGE DETERMINATION IN THE SKATE, *RAJA EGLANTERIA*. —Several attempts have been made to find a satisfactory method for determining age groups among the Elasmobranchii. Haskell (*Ann. Rept. Mar. Lab. Tex. Game & Fish Comm., 212–17, mimeo.*, 1948–49) described a silver nitrate technique devised to reveal the annuli in the vertebrae of a shark. Ishiyama (*Bull. Jap. Soc. Sci. Fish. 16(12):119–26,* 1951) examined a method for age determination of the Japanese black-skate, *Raja fusca,* based on the histological structure of the vertebral centrum and relating this to the statistical investigations of the size-frequency distribution and to the measurement of external characteristics. Fitz (*Masters Thesis, University of Delaware,* 1956) analyzed length-frequency distributions in an attempt to determine the ages of *Raja erinacea* and *Raja eglanteria* collected from Delaware Bay.

The clear-nosed skate, *Raja eglanteria,* enters the Delaware Bay area in considerable numbers. Analyses of its food habits along with several other elasmobranch species indicate considerable overlap in feeding with the more desirable commercial and recreational species. In order better to understand these interspecific relationships, rates of growth and other population characteristics, the development of reliable aging techniques for the elasmobranchs was imperative.

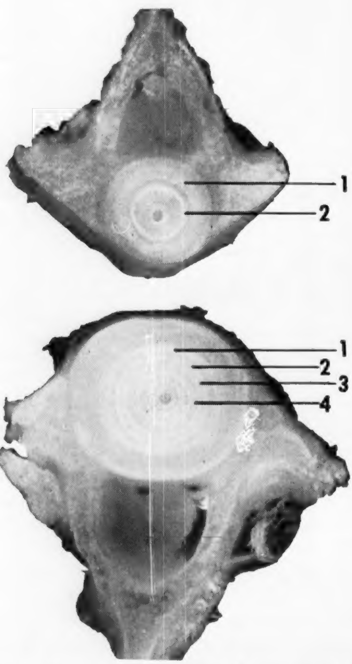

Fig. 1.—Centra of vertebrae from *Raja elganteria*, (top) with a disc-width of 31 cm., and (bottom) with a width of 45 cm. showing 2 and 4 opaque rings, respectively.

The purpose of this study was to determine whether or not distinct rings could be observed in the vertebral centra of the clear-nosed skate and whether there was any relation between their number and disc-width frequency distribution. Such a relationship could be used as a tool for recognizing age groups among the elasmobranchs as has been done among certain of the teleost fishes (Hooper, Copeia *1949(1):34*).

Procedure.—Six specimens of *Raja eglanteria* were taken by hook and line for preliminary analysis. The abdominal vertebrae from approximately the 10th to the 20th from the cranium were removed, preserved in formalin and subjected to the techniques described by Haskell, (*op. cit.*) and Ishiyama (*op. cit.*). Although these workers reported satisfactory results, we found them to be more involved than necessary.

Although several methods were attempted the following procedure was adopted. The vertebral sections were placed in 10 percent formalin where they remained overnight. They were then removed and all of the muscle tissue was scraped off. They were separated into groups of three or four and placed in 95 percent alcohol for approximately four hours. They were then put into absolute alcohol. Twenty-four hours later they were immersed in a substantial quantity (approximately 10 times the volume of the vertebrae) of xylene and allowed to remain overnight. The following morning the vertebrae were soaked in fresh xylene for about 12 hours. The vertebrae were immersed in melted paraffin in an oven at 60°C where they remained for 24 hours. The sections were then cleared in xylene for two to four hours. The connective tissue covering the biconcave surfaces of the centra was scraped away after the individual vertebrae had been separated. Opaque white rings alternating with gray translucent rings became visible to the naked eye. After six months storage in xylene these rings were still clearly visible. The rings were indistinct in vertebral specimens that had been stored in formalin for six months prior to processing.

Five hundred and seventy-two skates were taken from the general area of the Delaware Bay estuary from June 17 to July 21, 1959. Of this number, 272 were caught in the bay by a commercial otter trawl, six were taken by hook and line and the remainder were collected by trawl from the fishing grounds off Ocean City, Maryland. The disc-width and total length of the

animal were recorded to the nearest cm. along with the sex. From the 572 specimens measured, 222 samples of vertebrae were examined for rings by the method described above.

Observations and Discussion.—Fig. 1 shows the centrum of a vertebra from a 31 cm. skate and one from a 45 cm. specimen showing 2 and 4 rings respectively. Table 1 indicates the disc-width frequency distribution of the skates measured and of those that were processed for the presence of rings in the centra.

Table 2 reveals the number of rings in the centra of vertebrae counted for each disc-width interval from 24 cm. to 50 cm. of those specimens examined. This table shows a progressive increase in the number of opaque white rings found in the centra with increasing disc-width of the skates. Modal points are located at the 30, 34, 40, 46 and 48 cm. class intervals for the number of rings, 2 through 6, respectively.

The rings were counted by two people. There was a 70 percent agreement for the initial reading. A difference of more than one ring counted occurred only in two specimens. The distinctness of one translucent ring separating two opaque rings seemed to be the main source of difficulty in counting.

TABLE 1

DISC-WIDTH FREQUENCY DISTRIBUTION OF THE COMBINED SEXES OF *Raja eglanteria* AND THE NUMBER OF VERTEBRAL SECTIONS EXAMINED FROM THE DELAWARE BAY ESTUARY DURING THE SUMMER OF 1959

Disc Width in cm.[1]	Number of Skates Measured	Number of Vertebral Sections Examined
24	1	1
25	2	2
26	14	7
27	7	3
28	16	7
29	21	5
30	18	8
31	28	8
32	21	10
33	36	10
34	38	11
35	25	12
36	48	16
37	36	12
38	49	14
39	50	15
40	38	14
41	21	10
42	21	10
43	27	14
44	14	5
45	10	6
46	14	9
47	7	6
48	5	3
49	3	2
50	2	2
Total	572	222

[1] Total Length = 1.4065 × Disc Width + 5 cm.

TABLE 2

THE FREQUENCY DISTRIBUTION OF THE NUMBER OF DENSE WHITE RINGS FOUND IN THE VERTEBRAL CENTRA OF THE VARIOUS *Raja eglanteria* EXAMINED

Disc Width in 2 cm. Intervals	Number of Rings Counted											
	1		2		3		4		5		6	
	Q	C	Q	C	Q	C	Q	C	Q	C	Q	C
24	2	2	1									
26	6	4	4	4								
28	6	5	5	5								
30			12	12	3	2						
32			6	6	13	7						
34			1	1	21	16	1					
36					18	16	9	4				
38					13	10	16	10				
40					1		20	17	3			
42							19	13	5	2		
44							4	3	7	1		
46							4	2	8	6	3	
48									1		4	2
50											2	1

[1] Q—Frequency distribution of the number of rings counted from all specimens examined. C—Frequency distribution of the number of rings agreed upon after an initial reading made by each of two readers.

The number of rings in the animals with disc widths between 24 cm. and 28 cm. was difficult to determine. With reference to Ishiyama (*op. cit.*), the young animal has a calcified ring around the notochord which has evidently been deposited while still in the egg case. After hatching the skate appears to go through a period of growth characterized by a less densely calcified area in the centrum. The growth in disc-width during the period before the first ring is deposited approaches 24 cm. or the smallest size recorded in this study. The first ring of opaque material, then, is supposedly deposited before attaining a disc size of 28 cm. The enumeration of the two concentric rings in the 25, 26, and 27 cm. disc widths may be partially in error due to the difficulty in distinguishing distinct dense calcified bands in these size classes with the result that some of these animals may display only one growth period instead of the two counted.

Summary.—Dehydration, paraffin impregnation and xylene clearing appears to be an effective technique in demonstrating the presence of dense opaque rings alternating with translucent rings in the vertebral centra of *Raja eglanteria*. There is a definite relationship be-

tween the number of these rings and disc-width frequency distribution.

This work was carried out by James T. Williams of the Delmar, Delaware Junior High School and James M. Proudfoot of the Georgetown, Delaware High School, under the auspices of the NSF Research Participation for Teacher Training Program for 1959. Marine Laboratories Contribution No. 13.—FRANKLIN C. DAIBER, *University of Delaware, Newark, Delaware.*

FECUNDITY OF RAINBOW TROUT FROM ACTUAL COUNT OF EGGS.— Rounsefell (1957, *U.S. Fish and Wildl. Serv. Fish. Bull. 57(122):451–468*) and Nicholls (1958, *Aust. Jour. Mar. Freshw. Research 9(4):526–536*) have indicated the relative scarcity of published data on the fecundity of rainbow trout, *Salmo gairdneri*, especially as determined on individual fish by direct count. On November 5, 1958, the water supply leading into an earthern pond at the Humboldt State College fish hatchery (DeWitt and Salo, 1960, *Prog. Fish-Cult. 22(1):3–6, Fig. 1*) was accidentally shut off, resulting in the suffocation of 17 female rainbow trout. This paper records the fecundity of these trout as determined by actual count of eggs, and compares their fecundity with 31 additional females of the same brood spawned artificially January 3–27, 1959.

During October, 1957, rainbow trout were purchased from a private trout hatchery (Trout Haven, Gasquet, Del Norte County, California) to provide a brood stock for instruction in fish culture. These trout were the largest available at the private hatchery, weighing five to the pound, averaging seven inches in fork length, and were less than a year of age. Thus the trout killed November 5, 1958, and spawned January 3–27, 1959, were maturing at two years of age.

Ovaries from the 17 females were removed on the day of death, wrapped in cheese cloth along with an identifying number and preserved in formalin. The weight in grams and fork length in cm. of each female was determined at this time. Approximately a year and a half later, the ovaries were removed from the preservative, blotter dried, and weighed. After weighing, they were broken into large chunks, crumbled into a pan, and the ovarian tissue teased away and weighed in grams. The number of eggs in each ovary was counted. Weight of ovary, ovarian tissue, and number of eggs were recorded for each ovary. Accuracy of scale used in weighing the fish was 0.5 g., and in weighing ovaries and ovarian tissue, 0.1 g.

From January 3–27, 1959, 31 female trout were spawned artificially. On January 3, the eggs from six of 20 females spawned were selected and their eggs maintained as separate lots. The length and weight of these six fish were taken on date of spawning. The remaining 25 females spawned January 3–27 were not weighed or measured due to difficulties associated with the first year of actual fish cultural operations. For trout spawned during January the total number of fluid ounces of eggs produced was converted to total number of eggs by multiplication using the number of eggs per fluid ounce as determined by count of eggs in a two fluid ounce subsample. This fish-cultural work was performed by Mr. Kenneth Johnson, technical assistant in charge of operating the Humboldt State College hatchery under the supervision of Dr. Ernest O. Salo.

For the 17 trout (mean fork length 40.9 cm. and mean weight 965 g.) killed November 5, 1958, the average fecundity was 2,361 eggs (Table 1). This represented approximately 58 eggs per average cm. of fork length and 2,448 eggs per kilogram of body weight. For the six females (mean fork length 44.5 cm. and mean weight 1,280 g.) spawned January 27, 1959, the average fecundity was 2,512 eggs (Table 2). This represented approximately 56 eggs per average cm. of fork length and 1,962 eggs per kilogram of body weight. The remaining 25 females spawned during January, 1959, which were not weighed or measured, had an average fecundity of 2,505 eggs. The greater fecundity indicated for the fish suffocating November 5, 1958, might have been due to underestimation of number of eggs for the artificially spawned fish using volumetric method of estimation (Burrows, 1951, *Prog. Fish-Cult. 13(2):79–85*), but was most likely due to fish of greater average length having suffocated during the November 5 accident, although no data are available to substantiate the assumption. Some error was also due to retention of eggs in the fish spawned artificially, but was considered not over five percent due to extra care taken in handling the fish.

On the average, there were 161 more eggs in the left ovary than in the right ovary of the 17 females killed November 5, 1958 (Table 1). Of these 17 pairs of ovaries, 13 contained more eggs in the left ovary than in the right; however, the female having the highest fecundity showed 437 more eggs in the right ovary than in the left (No. 16, 3,459 eggs, Table 1). The weight of the ovaries and of the ovarian tissue showed the same general trend as the number of eggs which they contained. The ovaries averaged 11 percent of the body weight, which for these trout represented the condition approximately two months

Table I

Fecundity and Other Data Collected on 17 Rainbow Trout Brood Killed November 5, 1958.

Fish No.	Fork Length in Cms.	Weight in Grams	Number of Eggs			Total Weight of Ovary in Gms.		Weight of Ovarian Tissue in Grams		Percent Body Weight of Ovaries
			Left Ovary	Right Ovary	Total	Left Ovary	Right Ovary	Left Ovary	Right Ovary	
1	36.4	706.7	1,127	1,062	2,189	42.7	39.0	1.5	1.1	11.6
2	38.8	791.7	1,116	643	1,759	51.9	27.8	1.9	1.8	10.1
3	38.8	907.5	1,803	1,027	2,830	76.6	43.5	2.1	1.9	13.2
4	39.3	828.0	992	1,129	2,121	50.5	55.0	1.7	1.5	12.7
5	39.4	878.5	856	1,169	2,205	32.1	42.0	3.4	3.6	8.4
6	39.8	921.0	1,215	838	2,053	54.6	38.7	1.2	1.1	10.1
7	40.0	882.6	987	940	1,927	32.5	30.5	1.4	0.9	7.1
8	40.2	984.0	1,864	1,209	3,073	84.6	55.8	2.7	2.0	14.3
9	40.4	883.4	798	792	1,590	45.1	42.1	2.5	1.9	10.1
10	41.0	919.6	1,128	988	2,116	68.0	60.8	2.6	3.0	14.0
11	41.1	983.2	1,435	1,213	2,648	62.3	51.8	2.2	2.2	11.6
12	41.2	993.0	1,242	1,159	2,401	[illegible]	56.7	4.2	1.7	11.8
13	42.1	1,069.5	1,411	1,493	2,904	62.9	65.5	2.5	1.6	12.0
14	42.9	1,026.2	1,209	1,062	2,271	55.0	46.5	1.5	1.3	9.9
15	43.3	1,155.5	1,328	1,125	2,453	80.0	66.6	3.8	2.7	11.0
16	44.7	1,198.5	1,511	1,948	3,459	48.5	66.8	0.8	1.2	9.6
17	45.5	1,276.5	1,474	951	2,425	75.4	47.9	3.0	1.8	9.7
Average	40.9	965.0	1,264	1,103	2,361	57.8	49.2	2.3	1.8	11.0

Table 2

Fecundity of Six Rainbow Trout Selected and Spawned January 3, 1959, for Brood Stock

Fish No.	Fork Length in Centimeters	Weight in Grams	Estimated No. Eggs Produced
1	42.0	1,130	1,890
2	43.6	1,150	2,154
3	44.2	1,400	3,072
4	45.0	1,160	2,636
5	45.3	1,440	3,161
6	46.8	1,420	2,160
Average	44.5	1,280	2,512

prior to spawning. Mottley (1938, *Trans. Amer. Fish. Soc. 67:207–210*) found the ovaries averaging 19 percent of the mean body weight for wild rainbow trout taken just prior to spawning.

The relationship of egg number against both body weight and body length were rectilinear. This was undoubtedly due to two-year-old fish from a single year class in the sample which grew rapidly under similar conditions. Therefore there was relatively wide range in fecundity (1,590–3,459 eggs) in comparison to a relatively narrow range in fork length (38.8–45.4) and relatively narrow range in weight (707–1,198 g.). This situation is similar to that indicated by Donaldson and Olson (1957, *Trans. Amer. Fish. Soc. 85:93–101, Fig. 4*) for their 1953 brood year rainbow trout spawned as two-year-olds, and for rainbow trout from two Tasmanian lakes reported by Nicholls (*op. cit.*).

The average fecundity of 2,361 eggs for the 17 females of 40.9 cm. fork length killed November 5, 1958, is very similar to the average fecundity of 2,400 eggs found for steelhead trout of 40.0 cm. average fork length from Scott Creek, California (Shapovalov and Taft, 1954, *Cal. Dept. Fish and Game, Fish. Bull No. 98, Fig. 27*). Donaldson and Olson (*op. cit.*) for 51 females maturing as two-year-olds of 40.9 average and 45.0 cm. maximum fork length recorded an average of 2,145 and a maximum of 3,810 eggs produced. The 17 trout killed November 5, 1958, maturing as two-year-olds were of very similar size (40.9 average and 45.5 cm. maximum fork length) and had a very similar fecundity (2,361 average and 3,459 maximum eggs produced).—George H. Allen, *Assistant Professor, Fisheries, Division Natural Resources, Humboldt State College, Arcata, California*, and Gerald A. Sanger, *Conservation Fieldman II in Fisheries, Nevada Fish and Game Department, Reno, Nevada.*

NOTES ON THE ORIGINAL DESCRIPTION OF *MALACOSTEUS NIGER* AYRES AND SUBSEQUENT REFERENCES TO IT.—The first full description of this genus and species appeared in 1849 (*Boston Jour. Nat. Hist. 6(1):53–64*). The *Boston Journal of Natural His-*

tory was subtitled "containing papers and communications read to the Boston Society of Natural History. Published by their direction." Papers published in this journal had been given earlier at the meetings of the society. Another publication, *Proceedings of the Boston Society of Natural History,* carried the transcriptions of the actual meetings. In volume *III* of the *Proceedings* (1848–1851) (page 64) are the proceedings of the meeting of October 18, 1848, at which Ayres gave his paper on *Malacosteus.* Included in these proceedings is a passage in quotations, which would seem to be an author's abstract, as follows:

> "Mr. Ayres read a paper on a very curious fish which he exhibited to the society. It was taken at sea south of the Grand Banks of Newfoundland in 42° N. lat. and 50° W. long.... Mr. Ayres proposes for the genus the name *Malacosteus* and for the species, from its color *Malacosteus niger.*"

A description of the animal and two paragraphs of anatomical description, obviously from the text of the paper, were also given. These are followed by the passage "(For the paper in full see Journal of the Boston Society of Natural History Vol. VI. No. 1)".

A footnote on page 65 implies that these proceedings were published in November 1848. In the *Annual of the Boston Society Natural History,* 1868, and *Price List of Publications* 1904, there is ample evidence that until volume 27 *Proceedings* were issued as "sheets" or signatures and later accumulatively bound. Since this 1848 signature contained a description of the animal and a formal proposal of the name *Malacosteus niger,* it would appear that the 1848 *Proceedings* and not the 1849 *Journal* contained the original description.

Since these two papers, various authors (Gunther, 1864, *Cat. Fishes Brit. Mus., 5:427;* Jordan and Gilbert, 1882, *Bull. U. S. Nat. Mus. 16(3):287;* Goode and Bean, 1895, *Oceanic Ichth., 114;* Jordan and Evermann, 1896, *Bull. U. S. Nat. Mus. 47(Pt.1):592–3;* Jordan, 1919, *Genera of Fishes Pt.2:240;* Jordan, Evermann and Clarke, 1930, *Rept. U. S. Comm. Fish., (1928) app.x:71*) have consistently reported the original description as appearing in the "*Journal of the Boston Natural History Society*" which according to a recent letter from the U. S. Library of Congress is an inaccurate citation of the publication. According to C. M. Gottschalk, Head, Science and Technical Reference Section the citation should be:

"Ayres, W. O. Description of a new genus of fishes, *Malacosteus.* Boston journal of natural history, containing papers and communications read to the Boston society of natural history, vol. 6, no. 1, art, VI, pp. 53–64, 1849." For brevity the journal could be referred to as the *Boston Journal of Natural History,* but not the journal of the *Boston Society of Natural History.*

Jordan (1919) cited the title of the article appearing in the *Proceedings* in 1848 and not that of the article in the 1849 *Journal.* Various authors have given the date of Ayres' description as 1851 or 1857 as a result of the fact that the title page of vol. 6 of the *Journal* bears the dates "1851–1857". Fowler (1936, *Bull. Amer. Mus. Nat. Hist. 70:206*) refers to the *Proceedings* article, gives the 1851 date of the bound volume but he lists this article above the 1849 *Journal* article in his list of synonymy.

No less than four of the later references incorrectly gave the location of capture, as follows: 40° N. lat., 50° W. long. (Goode and Beane, 1895) and 42° N. 60° W. (Jordan and Evermann 1896, Jordan, Evermann and Clark 1930, Fowler 1936).

There is an error in the abstract appearing in the 1848 *Proceedings* version. The size is given as 8¼ inches there and as 8½ inches in the *Journal* article (1849).—E. J. CROSSMAN, DEPT. FISHES, ROYAL ONTARIO MUSEUM, TORONTO, 5, ONTARIO.

MICROPOGON ECTENES JORDAN AND GILBERT A SYNONYM FOR *MICROPOGON ALTIPINNIS* GÜNTHER.—In describing *Micropogon ectenes* from Mazatlán Jordan and Gilbert (*Proc. U.S. Nat. Mus., Vol. 4:355,* 1881) noted that this species was very closely allied to *Micropogon altipinnis* of Panamá. The major difference between the species is the number of

TABLE 1

SOUTH-NORTH VARIATION IN THE NUMBER OF RAYS IN THE DORSAL FIN OF *Micropogon altipinnis*

Approximate Latitude	Locality	No. of soft dorsal rays							Mean
		20	21	22	23	24	25	26	
8 08′N	Panamá	4	4	1					20.7
8 10′N	Taboga, Panamá			2					22
15 58′N	Puerto Arista				1				23
16 55′N	Acapulco			2	1				22.3
17 58′N	Petacalco				2	2	1		23.8
19 00′N	Manzanillo					1			23
21 30′N	San Blas			1					22
23 00′N	Cape San Lucas					1			23
23 05′N	Mazatlán				1	1	2		24.2
26 40′N	Yavaros					1	2	1	25

rays in the soft dorsal fin (24–26 in *M. ectenes* and 20–23 in *M. altipinnis*). Jordan and Gilbert also noted a slight difference in the number of scales along the lateral line (53 in *M. ectenes* and 48–50 in *M. altipinnis*). Examination of thirty-one specimens from Mexico and Panamá in the collection of the Institute of Fisheries, University of British Columbia, indicates a cline in the number of dorsal rays in *Micropogon* (Table 1). Because of this cline the number of dorsal rays cannot be used to distinguish *M. ectenes* from *M. altipinnis*. These specimens also indicate that there is no difference in the number of scales along the lateral line between *M. ectenes* and *M. altipinnis*. The number of scales in Mexican specimens ranges from 48–55, and in Panamanian specimens ranges from 47–54. No other characteristics were found which would distinguish *M. ectenes* from *M. altipinnis*. For these reasons *M. ectenes* should be considered a synonym of *M. altipinnis* Günther (*Proc. Zool. Soc. London, 149:1864*).—J. D. MCPHAIL, *Institute of Fisheries, University of British Columbia, Vancouver, Canada.*

REVIEWS AND COMMENTS

PHYLAX TELESCOPUS—III

In days of yore (not so very long ago, either) there were not very many ichthyologists and herpetologists in North America and the curators of the relatively few large research collections of fishes, amphibians and reptiles were the principal contributors of extensive systematic monographs on these creatures. Usually, each depended chiefly on his own collection for research material, and borrowing from other collections was rare. Later, it became increasingly the fashion for each monographer to borrow from other museums. Finally, the idea became fixed in many researchers' minds that no systematic paper could possibly be considered complete until its author had seen every available specimen in every known collection on the North American continent. This idea seems still to be prevalent amongst herpetologists, although ichthyologists, who usually have access to much larger numbers of specimens, have begun to find that the practice reaches a point both of diminishing returns and of diminishing ability to cope with mountains of material.

The effect of the "I-must-see-it-all" theory on museums and museum curators has scarcely been mentioned, except privately by the unfortunate caretakers of the larger collections, on whom the chief burden falls. Colleagues who are willing to travel to study distant collections are usually welcomed—if they are courteous enough to time each visit so that it will not inconvenience the local staff. It is principally the borrowers who become a nuisance. All curators are familiar with a few thick skinned and completely selfish workers who borrow large and important identified collections from various museums and never return them except under duress applied through the president or director of the borrower's institution. Even these are not a continuous bother, for they are rare.

The real trouble comes through the annually increasing number of sincere and often able younger workers, both professionals and students, who entertain the strange belief that entry into ichthyological or herpetological research automatically confers on them the right to demand as much material as they wish from any and all museums in the country. It never seems to occur to some of them that they are asking for a great deal of work to be done (equals money spent) in their behalf, or that the curator and his assistant may be fighting for time of their own for research or other duties. The borrower may pay postage or express charges, but that is the least of the expense and trouble.

Requests (or demands) of this sort usually come from individuals who have never had the tough and enlightening experience of caring for or administering a large research collection, hence of fulfilling numerous requests such as they themselves make. With labor cost as close to professional pay as it is in the United States, almost no museum department in the country is sufficiently staffed to operate well, let alone process numerous loans. The curator usually has to find and survey the requested material him-

self—for no one else is likely to know much about it—and the assistant curator usually does the sorting, invoicing, bottling, packing, and mailing, and the same in reverse when the specimens are returned. We estimate the average cost of processing each specimen for shipment on loan to be, in most museums, not less than 50 cents, chiefly in the time spent in doing the job. This means that any person who requests the loan of 50 specimens is, quite literally, asking some museum for a $25 gift to support his own research.

Of course, lending specimens is a reciprocal thing, or it would not exist. You borrow from us and we borrow from you. We doubt that any museum, even the National Museum, is legally bound to lend *any* material to anybody. Municipally or state supported institutions are certainly not bound to lend anything outside the city or state from which they derive support. Curators in private, endowed institutions, such as Harvard, Tulane, or Stanford, could undoubtedly prevent any or all outsiders from even looking at research material in their museums if they cared to do so. However, scientific freedom and responsibility being what it is, we know of no such act having occurred, and reciprocity is generally and rightly assumed. The trouble is that some borrowers forget reciprocity. Many requests come from institutions which maintain no collections, or only small ones from which there is no call to borrow. Yet these borrowers seldom recall the fact that they are demanding services that they are in no position to repay.

We have no ready solution to this problem. All we can say is that workers in institutions which do not maintain extensive collections of their own, open to borrowing, have no moral or legal right to expect loans to be made to them unless they offer to pay (out of their own research funds) a great deal more than transportation costs. Even workers in institutions with growing but not yet important collections, should be aware of their own responsibilities, and not ask for services they cannot repay. Especially they should be considerate enough neither to set their students at problems for which their facilities are woefully insufficient, nor to expect part of their student training to be supported by demands on other institutions.

* * *

The production of electricity by certain fishes has engaged the attention of many biologists and physicists, for fishes are the only animals known to possess electrical organs, and these have been separately evolved in at least four well known living groups—mormyrids, gymnotids, electric catfishes and torpedinid rays. H. W. Lissmann of Cambridge University has recently published some studies on electric organs, which should be of general interest ("On the function and evolution of electric organs in fish", 1958, *J. Exper. Biol.*, 35:156–191; Lissmann and K. E. Machin, "The mechanism of object location in *Gymnarchus niloticus* and similar fish", 1958, *tom. cit*: 451–486).

Lissmann finds that both mormyrids and gymnotids maintain electric fields about themselves, apparently for purposes of navigation, for they have shown extreme sensitivity to influences affecting the electric field, and can apparently locate objects by such means if the electrical conductivity of the objects differs from that of water. Prey does not seem to be affected by the discharges, but the latter have a social significance for the fish. The mormyrid *Gymnarchus* and the gymnotids *Hypopomus* and *Eigenmannia* emit very regular series of continuous, monophasic pulses of a frequency range between 60 and 400 discharges per second. Frequency does not alter with excitation of the fish. Other mormyrids, and the gymnotids *Gymnotus* and *Steatogenys*, emit a discharge less regular in frequency, but rising steeply with excitation. When resting, mormyrids of this second type show a somewhat unrhythmical discharge rate usually between one and six pulses per second. Excited fishes increase the rate to a recorded maximum of 130 per second. Gymnotids of the second type show a higher discharge rate which is regularly rhythmical and rises with excitation.

The experiments on the perception by *Gymnarchus* of glass rods hidden in porous pots suspended in the aquarium are most interesting and must be regarded as conclusive, for Lissmann and Machin were able to eliminate any reasonable possibility that optical or chemical stimuli were involved. Other experiments were also intensely interesting, but for them we must refer the reader to the original papers. Truly, the adaptations and specialization of fishes seem to be endless.

* * *

Frogs have proved to be among the most difficult of all animals to classify in the natural manner. They are, as a group, highly but narrowly specialized creatures, evolved to feed and protect themselves almost solely by continuous, statuesque immobility, punctuated by instantaneous feeding or jumping reactions. To attain perfection in this pervading specialization, they long ago developed a shortened vertebral column and strong hind legs, and have lost the tail. In many ways they have become simplified, as

well as confined within a rigid pattern of anatomy and behavior. Moreover, the intricate fugue which evolution has played on the restricted scale of frog anatomy has necessarily involved a bewildering variety of parallelism and convergence—so much, in fact, that the basic phyletic theme becomes very difficult to trace. No one in the past has erected what he believed to be a phylogenetic classification of the Salientia that has not gradually been torn down by the researches of his successors. Cope, in 1865, provided the first such classification, which, after being tidied up by Boulenger in 1882, survived in modified form until Noble published his "Phylogeny of the Salientia" in 1922. Since 1922, an increasing amount of research has badly shaken some of Noble's main conclusions, and we have hoped that another Cope or Noble might arise to attempt a better general system instead of merely whittling at details of the old.

Such a person appears to have arrived. Ivor Griffiths' "The Phylogeny of *Sminthillus limbatus* and the status of the Brachycephalidae" (1959, *Proc. Zool. Soc. London*, 132:457–487, 4 pls.) represents one stage of an investigation which, so its author promises, will result in a new "Phylogeny of the Salientia", now in manuscript. With access to the unrivalled collections of the British Museum and to the sound and experienced advice of H. W. Parker, Griffiths has applied wide knowledge and a variety of anatomical investigations to the several problems involved in the relationships of *Sminthillus* and the status of the "Brachycephalidae" of Noble. These matters touch on some of the central problems of frog classification, and the results are correspondingly interesting. Griffiths finds reason to reject both the arrangement of the thigh muscles and the nature of the vertebrae as prime classificatory characters, and concludes that the extent of fusion of the epicoracoid cartilages is incapable of exact taxonomic use. He upholds the value of the firmisternal and arciferal divisions first recognized by Cope, pointing out that the supposedly intermediate condition in *Sminthillus* is not so in fact. The real difficulty, according to Griffiths, is not one of intermediateness but of proper definition of the groups. He states that two main divisions of the Salientia, corresponding to the Arcifera and Firmisternia, can be precisely defined by the presence, in the former, of two posteriorly directed epicoracoid horns, lying closely against either side of the sternum, and their absence in the latter group. The three species hitherto referred to *Sminthillus* are referred to three separate generic offshoots of the *Eleutherodactylus* group. The family Atelopodidae is redefined to include only the firmisternal genera *Brachycephalus* and *Atelopus*, the remaining arciferal forms being referred to the Bufonidae. The Rhinodermatidae are transferred *in toto* to the *Leptodactylidae*, which must be enlarged to include "arcifero-firmisternal" forms. Finally, *Dendrobates, Hyloxalus* and *Phyllobates* are referred to a special subfamily of the Ranidae.

These are important conclusions, and deserve the utmost attention. We anticipate Dr. Griffiths' further researches with great interest.

* * *

Russian works in herpetology are beginning to appear, although few of them are more than identification manuals. S. A. Chernov's reptiles of the Tadzhik Republic (Reptiles. Fauna of the Tadzhik SSR, vol. 18. [In: *Academy of Science of the Tadzhik SSR, Trudy*, 98: 204 pp.] Stalinabad, 1959) is a summary account of the Tadzhik species, followed by a brief distributional chapter. Approximately 60 species are keyed out, some of these, however, being extralimital forms not formally covered in the text. The genera treated are herewith listed, those containing the majority of the species being starred: *Testudo, Teratoscincus, Crossobamon, Gymnodactylus, Alsophylax, *Agama, *Phrynocephalus, Varanus, Ophisaurus, Lacerta, *Eremias, *Ablepharis, Eumeces, Typhlops, Eryx, Natrix, Lycodon, *Coluber, Elaphe, Boiga, Taphrometopon* (the only endemic snake genus of North-Central Asia), *Naja, Vipera, Echis*, and *Ancistrodon*. The author's literature sources include much non-Russian literature (some in Copeia) and the treatment is a reasonably modern one. There are, unfortunately, almost no illustrations, even distributional maps being few in number.

* * *

We note here the beginning of a major Russian ichthyological work which should receive a formal review when more (or all) of it has appeared. It is "Fishes of the Sea of Japan and adjacent parts of the Okhotsk and Yellow Seas", by G. U. Lindberg and M. I. Legeza, Part 1, Amphioxi, Petromyzones, Myxini, Elasmobranchii, Holocephali (In: *Keys to the Fauna of the USSR published by the Zoological Institute of the Academy of Sciences of the USSR*, no. 68: 208 pp., Moscow and Leningrad, 1959). This is a first class, well illustrated manual, which takes into account the latest in world literature. The book closes with a good bibliography, a gazetteer of localities, and an index. We would protest only the attempt of the

authors (or perhaps an editor) to replace *Branchiostoma* by *Amphioxus*.

* * *

For a number of years, when lecturing to advanced students in ichthyology at Stanford, we have regularly mentioned the rare and little known "garden eels" (Heterocongridae) of tropical seas, which live in colonies, each eel half hidden in its own burrow and the heads of all members of the colony pointed in the same direction. Herre has described the colonies in the Philippines and Beebe those off Lower California, while Böhlke has recently contributed to their systematics. Now Klausewitz and Eibl-Eibesfeldt have contributed another chapter to the history of these strange eels, including classification, new forms from the Indian Ocean, and observations on the habits (1959, *Senckenbergiana biol.*, 40:135–153). Most interesting of all are the ecological and habit notes, including excellent undersea photographs of colonies of two different genera on sandy bottom in the Maldives and Nicobars.

* * *

Finally, we must mention the latest attempt to make geographical and taxonomic sense of the races of the fire-salamander ("Der Feuersalamander, *Salamandra salamandra* (L.), Beiträge zu einer taxonomischen Synthese", by Joseph Eiselt, 1958, *Abh. Ber. Naturk. u. Vorgesch.*(Magdeburg), 10 (6): 77–154). Eiselt carefully discusses individual characteristics, which are graphically set forth, geography, and breeding habits. Eleven subspecies are recognized.—G. S. MYERS, *Stanford University, Calif.*

COMMENTS

PROFESSOR MYERS ON THE *HISTOIRE NATURELLE DES POISSONS*.—Recently (Copeia, 1960, 1:76) Myers has criticized certain unnamed colleagues for efforts to clarify the crediting of authorship to species described in the *Histoire Naturelle des Poissons*, a work in which each volume bears the names of Cuvier and Valenciennes on the title page, but for which the actual authorship is clearly indicated in the tables of contents. Since my name is closely identified with this effort (*Copeia*, 1951, *3:249–251; Bull. Zool. Nomencl.*, 1957, *13 [10/11]:309–312*) and since Professor Myers' comments include superficially appealing though irrelevant arguments that confuse the issue, I feel impelled to respond.

The case for citing Cuvier *or* Valenciennes as author of new species appearing in the *Histoire Naturelle* has been fully stated in the papers cited above and need not be repeated here. It should be noted, however, that this is not a question of personal preference but one of application of the international Rules of Zoological Nomenclature. It is not a novel suggestion. Contemporaries and successors to Valenciennes, including such knowledgeable nineteenth-century ichthyologists as Storer, Poey, and Moreau, were among those who cited single authority for new names in the *Histoire Naturelle*. Myers remarks facetiously that if "such sticklers for nomenclatural accuracy wish further occupation" they examine other works of joint authorship to establish parallel separate assignment of credit. He nominates several, but fails to call attention to the key point in such determination: is authorship of the pertinent sections clearly ascribed otherwise than on the title page in the original publication? If so, reconsideration of authorship is indicated. In most if not all of Myers' gratuitous nominations, extrinsic information is necessary to establish true authorship. Hence, the reader must rely on the only clear statement of authorship provided.

The request for a definitive ruling on the question by the International Commission on Zoölogical Nomenclature was published in the *Bulletin of Zoological Nomenclature* in 1957. Several letters, none by Myers but one expressing roughly the same objections raised by him, were received by the Commission. Earlier, in the hope of enlisting his counsel, I had sent Dr. Myers the manuscript of the note on the authorship of species in the *Histoire Naturelle* prior to its appearance in Copeia in 1951, but he did not reply.

Opinion 580 of the International Commission on Zoölogical Nomenclature was certified 1 May 1959 and issued in December, 1959 (*Bull. Zool. Nomencl., 17 [3–5]:148–152*). It rules in part: ". . . .new names included in Volumes 2 to 22 of the . . . .*Histoire Naturelle des Poissons* . . . are to be attributed to Cuvier *in* Cuvier and Valenciennes, or, as the case may be, to Valenciennes *in* Cuvier and Valenciennes . . . ." Thus, Myers' remarks in 1960 seem curiously ill-timed.

Dr. Myers' closing comment is not really relevant to the point at issue. He states, "Personally, we shall continue to quote all 22 of the volumes of the *Histoire* as by Cuvier and Valenciennes." So shall I. This is a citation of the work and both names appear on the title page and in bibliographic sources. However, if workers respect the International Commission's ruling, here based on considered judgment of the spe-

cific work, they will credit authorship of new species as specified in the schedule included in the ruling of Opinion 580.—REEVE M. BAILEY, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

THE EGG MASSES OF NEOTENIC *AMBYSTOMA GRACILE*.—The recent paper by Knudsen (COPEIA 1960(1):44–46) on courtship behavior and the egg masses of *Ambystoma gracile* and *A. macrodactylum* presented new information on a number of features concerning the reproductive activities of these salamanders. The deposition by two neotenic *A. gracile* of egg masses "firm and indistinguishable from those of adults, except for numbers of eggs" that "were attached to vegetation" (p. 46) was described. In discussing a previous description of the egg masses of neotenic *A. gracile* (Snyder, COPEIA 1956(1):41–50) Knudsen has made several errors in interpretation.

The egg masses of *gracile* were ".....of a loose, tenuous consistency, not firm as in the case in adult egg masses"; further, "A few bunches were attached to grass stems, but most lay free on the bottom" (Snyder, *op. cit.*, p. 44). The evidence that these eggs were those of *A. gracile* larvae is that 240 larvae were collected in company with and in close proximity to the numerous masses of freshly deposited eggs, some of which were attached to grass stems growing in the drainage ditches; furthermore, eggs from these masses developed normally (p. 45) into *A. gracile* larvae. Some of the Weiss pond larvae were maintained for a year in this laboratory before preservation and are now in the Department of Zoology, University of Washington, collection. There is not even a remote possibility of misidentification of the egg masses as Knudsen (p. 46) implied.

Knudsen (pp. 45–46) claimed that the evidence for the remarks quoted above and for the identification of the eggs was based on the collection of "large quantities of such eggs (50 gallons) from a drained pond in which no adult *Ambystoma* were found but in which 240 larvae, identified as *A. gracile*, were collected during a two-day search (which began fully one day after the eggs were collected)". To this statement I comment as follows: 1) The 50 gallons of eggs clearly refer to eggs of *A. gracile* and *Rana aurora* removed from the pond by Mr. Weiss prior to the draining operation. These eggs were not collected by me. 2) The search for larvae did not begin the day after the eggs identified as larval masses were collected. It began the day after Mr. Weiss removed eggs from the pond. 3) The 240 larvae "along with numerous masses of freshly deposited eggs" (Snyder, p. 44) *were not collected in the pond*, but in the drainage ditches.

Kundsen stated (p. 46) that my description of larval egg masses agreed with that of Slater (COPEIA 1936(4):235) and of Knudsen, "but for *Ambystoma macrodactylum* and not for *A. gracile*", and that "Snyder's description for *A. gracile* neotenic egg masses is identical with descriptions of [those of] adult *A. macrodactylum*." The latter statement is not correct. The descriptions agree only in the manner of deposition; they do not agree in the size of the mass or the numbers of eggs. I am quite familiar with the eggs of *A. macrodactylum*, have collected them many times and have observed their deposition in the field. Slater (*ibid*, p. 235) and Knudsen (p. 44) both indicated that *A. macrodactylum* lays single eggs or small masses of 10 to 15, which is correct. The masses I collected in the drainage ditches varied from "small clusters of 15 to 34 eggs, to large masses containing up to 143" (Snyder, p. 44). Knudsen makes no attempt to explain the soft egg masses of *A. gracile* collected in the cold Mt. Rainier ponds (Snyder, p. 45) or the similar masses deposited by larvae of this species in cold, running water in this laboratory.

It is entirely possible that on occasion or under conditions not yet understood, neotenic *A. gracile* may deposit egg masses indistinguishable from those of transformed adults; in fact, in view of the evidence presented by Knudsen on the mating of neotenic and transformed animals, this is probable. The hypothesis that neotenic forms lay soft egg masses was based not only on the events observed at the Weiss pond, but also on the collection of similar masses in other lowland and mountain ponds where there is a known high percentage of neoteny in the populations. But it remains a hypothesis. When collecting eggs in any pond, it is often impossible to be sure of their source.—RICHARD C. SNYDER, *Department of Zoology, University of Washington, Seattle, Washington.*

REVIEWS

EXPÉDITION OCÉANOGRAPHIQUE BELGE DAN LES EAUX CÔTIÈRES AFRICAINES DE L'ATLANTIQUE SUD (1958–1959). RÉSULTATS SCIENTIFIQUES. POISSONS. Vol. 4, Fasc. 1, 1951 (GÉNÉRALITÉS, SÉLACIENS ET CHIMÈRES, 154 pp., 8 pls.), Fasc. 2, 1953 (TÉLÉOSTÉENS MALACOPTERYGIENS, 258 pp., 8 pls.). Fasc. 3A, 154

(TÉLÉOSTÉENS ACANTHOPTÉRYGIENS, Première Partie, 390 pp., 9 pls.), Fasc. 3B, 1959 (TÉLÉOSTÉENS ACANTHOPTÉRYGIENS, Deuxième Partie, 417 pp., 7 pls.) By Max Poll. Institut Royal des Sciences Naturalles de Belgique, Bruxelles.—Completion of the bulkiest recent report (over 1200 quarto pages) on the ichthyological results of an oceanographic expedition is in itself an achievement. When the report deals with an area as little known as the Atlantic Coast of Africa, it becomes still more important. We must congratulate Dr. Poll on a truely herculean achievement, the more so because during the work he was also maintaining a prodigious output of publications on the fishes of the Congo and Lake Tanganyika.

The fishes included were almost all bottom forms obtained by trawling in coastal waters, and include the majority of species previously obtained by such methods from the Equator to 22°30′ South along the West African coast, including the expected increment of new forms. Relatively few bathypelagic or really deep water bottom fishes were obtained. However, most species are well figured, all are described, and the report will probably long stand as the most important account of the fishes of the continental shelf for the area covered.

This report is an illustration of what can be accomplished by an industrious, quick, and able ichthyologist when he is given plenty of subprofessional assistance and thus freed from a great deal of curatorial and administrative work. Unfortunately, few such men in America are given such a free hand—nor, if one were, would funds for such lavish publication of his results be forthcoming. Moreover, the trend in systematics in most parts of the world nowadays is towards much more restricted world-wide revisional studies of individual groups, or at least a much more penetrating consideration of the world literature of groups treated in collection reports. It is clear that the latter was impossible during Dr. Poll's massive task, for a number of instances of neglect of the pertinent non-African literature occur in this report. Perhaps of more general import is the passing over, without comment in the brief general sections, of the excessively peculiar zoogeographical features of the West African tropical marine shore fish fauna. However, reports such as the present one must be viewed as pioneer attempts to make a little known fauna better known, and Dr. Poll deserves the thanks of all ichthyologists for having provided such a wealth of detailed information. Finally, this report, like those issued by many European countries, points out again the practical as well as what we may call the prestige value of having oceanographic reports published in a permanent form commensurate with the excessive cost of operating the vessels—a subject to which those who handle the enormous bulk of American oceanographic funds seem to be myopic if not completely blind.—George S. Myers, *Stanford University, California.*

MOSTLY ABOUT MUSEUMS. From the papers of A. E. Parr. The American Museum of Natural History, New York: 112 pp. 1959.—The reviewer has deep but mixed feelings about this book. For the first time, within the covers of one slim volume, a great deal that badly needs to be said about natural history museums has been said. No one who presumes to run, or help run, or direct, or work in, or make decisions regarding the establishment or operation of a natural history museum—public or university—should fail to ponder deeply everything the author says. Dr. Parr has had long experience as director of America's largest natural history museum. And he has thought much more deeply about the purposes, functions, needs, and philosophy of museums than it is fashionable for museum directors—or even the scientific staffs which populate museums—to think. The reviewer thoroughly agrees with most of what the author says, but there are exceptions. The fact that Dr. Parr's personal museum experience has been first, in an extremely specialized small museum organization and, second, as director of a gigantic public metropolitan museum, at once gives the book both its favor and its weakness. There seems to be little point in dwelling upon the latter, except to say that the reviewer, with long first-hand experience in curatorial and executive capacities in five different museums, including one very large public museum outside the United States, finds numerous passages in which Dr. Parr's thinking is, in some (but seldom in all) respects, either idealistic or applicable principally to his own museum and to few others. One vital thing which Dr. Parr fails to appreciate is that most of the great research collections are possible and survive only because of the unstinted care bestowed upon them by those comparatively few biologists who have that "spirit of the collector" against which he inveighs. Where that spirit is absent, the collections quickly go to pot, even when plenty of support is provided. Yet Parr is so incontrovertably right about many things which most museum workers think about only fuzzily that what he says insistently nags one.—George S. Myers, *Natural History Museum, Stanford University, California.*

Editorial Notes and News

Recent Deaths

DR. OTTO SCHINDLER, the well-known German ichthyologist of the Zoologischen Staatssammlung in Munich, died from a heart attack on September 4, 1959, while on an expedition in Poitiers, France, according to news from DR. W. HELLMICH of the same museum. Born in Vienna on December 1, 1906, he completed his graduate studies there in 1930. After two months residence at Plymouth, he worked at the Natural History Museum in Vienna until March 1931, after which he became permanently attached to the Zoologischen Staatssammlung des Bayerischen Staates. Starting as a student, he became an Assistant in April 1939, and Curator and Chief of the Department of Ichthyology in January 1945. After the War in 1956, he was promoted to Chief Curator. He became Superior Curator in January 1959. During the interim, he participated in an expedition to South Brazil in 1937–38, and to Bolivia in 1953–54.

His first publications dealt with the developmental history of European freshwater fishes, but he soon began to work on taxonomic problems. He published in 1935 a paper on the cyprinodont fishes of Costa Rico, in 1939 an account of the South Brazil expedition, and a study of the saibling of the Konigsees in 1940. His special interest was devoted to limnology and fishery biology; some of his important works dealt with limnological work on the Konigsee, the Walchensee, and Lake Titicaca in Bolivia. From 1953 to 1955 he worked on an extensive catalogue of fishes for the Kosmos-Lexikon Encyclopedia. He was widely known for a popular book which was published in German (1st edition 1953, 2nd edition 1959) and which was transulated into English in 1957. He left many important projects unfinished, including an account of the ichthyological material collected by Peters in San Salvador and a monograph on the Loricariiden. He collaborated with DR. W. KLAUSEWITZ of Frankfurt a. Main in the editing of "Ichthyologischen Schriftennachweis," of which six parts have been published.

Despite the difficulties following the War, DR. SCHINDLER succeeded in rebuilding the department and fish collection, which had been completely destroyed, to one comparable to the old collection. An important figure in ichthyology, fishery biology and management, and limnology has been lost to science.

CONRAD LIMBAUGH, Chief Diving Officer at Scripps Institution of Oceanography, University of California, La Jolla, drowned on March 20, 1960 at the age of 35, during an exploration of subterranean waters along the Mediterranean coast of France, at Port Miou, near Marseilles. He had just attended a panel meeting of the International Underwater Confederation at Barcelona, Spain, where he had been recognized and honored by being elected to membership in the Board of Directors of that organization, and as chairman of the newly created section on marine biology.

News of his death came as a great shock, for he was widely recognized as an authority on safety precautions in SCUBA diving, and had put hundreds of students through a rigorous diving course. He was frequently called into consultation by military and civilian agencies concerned with diving and with the scientific information that can accrue from underwater observation.

LIMBAUGH was the author of numerous reports, popular articles, and scientific papers, on diving, the life history of fishes, the fish life of the kelp beds, the biotic effects of ocean pollution, submarine canyons, etc. He had in preparation a series of manuscripts on such diverse topics as shark behavior and shark attacks, the symbiotic cleaning behavior by which certain shrimps and fishes rid cooperative larger fishes of parasites, and the habits and life histories of various fishes. He was working on

numerous problems, including the physiology of diving, underwater photography, and the distribution and ecology of various fishes, sea mammals, and invertebrates.

"Connie," as he was very widely known, contributed often, effectively, and generously to the researches of others. He was surpassingly proficient and accurate as an observer and interpreter of natural events, and brim full of contagious enthusiasm.—CARL L. HUBBS.

Foreign News RUSSIAN ICHTHOLOGY.—DR. VICTOR M. MAKUSHOK, in a recent letter to DR. LEONARD P. SCHULTZ, Smithsonian Institution, gave a general review of ichthyological work in progress in the USSR. At the Zoological Institute, Leningrad, DR. A. P. ANDRIASHEV is responsible for all material from the Antarctic and Arctic regions, mainly obtained by the "OB" during the IGY. He has finished his "The fishes of the Arctic Seas of the USSR," 1955. Besides, he is responsible for Zoarcidae, Cottidae (both groups are abundantly represented) and Liparididae.

DR. A. N. SVETOVIDOV, who is with Institute of Oceanology, Academy of Sciences, USSR, is responsible for Gadidae, Clupeidae, and material from the Black Sea and is preparing a systematic guide for the fishes of that area. He is also responsible for the Stichaeoidae of the Zoological Institute.

PROF. G. U. LINDBERG and his assistant, MRS. M. I. LEGESA are responsible for Cyclopteridae, Agonidae, and for material from the Sea of Japan.

MR. V. V. BARSUKOV is responsible for Anarhichadidae and Scorpaenidae (*Sebastes—Sebastodes* complex). He is going on an expedition to the Sea of Japan and Ochotsk Sea (April–September, 1960). The Coregonidae, Cyprinidae, Osmeridae and other groups are without masters at present.

Work at the Zoological Museum of Moscow University was summarized as follows:

In this museum there is amassed chiefly freshwater material from the Amur Basin, the Petchora River (westwards from the northern Ural), from Middle-Asian areas, including the Aral Sea, and other regions. For these collections MRS. ALEXANDRA A. SVETOVIDOVA, Chief of the Ichthyological Laboratory, is responsible.

At the Institute of Oceanology, Moscow are the deep-sea collections (except Zoarcidae, Brotulidae, some Liparididae which are in the Zoological Institute), and some pelagic fishes. All of these were procured by the "Vityaz" during post-war cruises.

MR. N. V. PARIN has studied the Exocoetidae; MRS. Y. B. KULIKOVA the Myctophidae, except some specimens were studied by PROF. T. S. Ross, however these fishes need further determination.

DR. T. ROSS, head of the laboratory is on the "Vityaz" in the Indian Ocean and will return about May, 1960.

DR. VICTOR M. MAKUSHOK will revise more fully the Stichaeoidae, and then the Atlantic Macrouridae. He expects to go to the Indian Ocean in late 1960 on the "Vityaz" for several months.—LEONARD P. SCHULTZ.

German Biological Station.—The new marine Biological Station of Heligoland, Germany was formerly decided in June 1959. The divisions of activity provided for under the general leadership of DR. A. BUCKMANN, director of the new station who remains resident in Hamburg where he is professor of fisheries biology in the University of Hamburg, are: zoology, animal physiology, botany, microbiology, planktonology and fisheries biology. The first of these divisions has a staff of three scientists with the Director as leader. The facilities include laboratories for staff, guest workers and students, the public aquarium, and the station's cutter UTHORN.

PROF. J. R. HENDRICSON, who joined the staff at the University of Malaya (in Singapore) in 1951, was recently appointed to the chair of Zoology. Trained at the University of Arizona and at the University of California at Berkeley, he is a vertebrate zoologist with wide experience and with special interests in herpetology and ecology. His study of the biology of the green sea turtle is well known, he has extensive experience with the fauna of the Malayan jungle, and an unusual fluency in colloquial Malay.

ROBERT G. SNIDER has been appointed coordinator of U. S. and international activities in connection with the forthcoming multi-nation oceanographic expedition to the Indian Ocean. He is president of International Population Research, Inc., and chairman of the panel on ocean resources of the committee on oceanography of the National Academy of Sciences—National Research Council.

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